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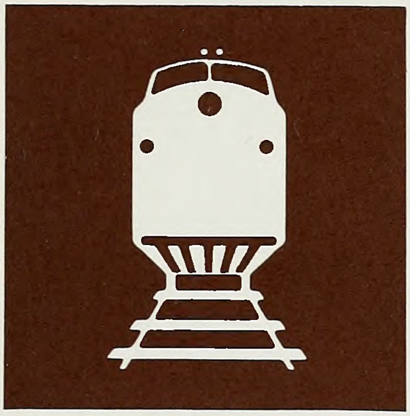

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Coastal Energy Impact Program
Office of Coastal Management
North Carolina Department of Natural Resources
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MITIGATING THE IMPACTS OF ENERGY FACILITIES: A LOCAL AIR QUALITY PROGRAM FOR THE WILMINGTON, NORTH CAROLINA AREA

BY

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1. Summary

Energy development in the coastal zone of North Carolina could change dramatically over the next ten years depending on the outcome of offshore oil exploration. It is already clear that outer continental shelf (OCS) oil and gas exploration and peat mining and use could dominate regional impacts. At the same time other industrial and recreational facilities cumulatively can have major environmental, recreational, health, safety and socioeconomic impacts.

This project is intended to help design a system of air quality analysis and review which will serve to anticipate and work to mitigate energy facility-related air quality impacts in the Wilmington Area. It was funded in part by the Coastal Energy Impact Program (CEIP), which was establish by Congress in 1976 to help states and local communities deal with the social, economic, and environmental requirements of coastal energy activity. Specific federal regulations implementing the program can be found in the Code of Federal Regulations (15 CFR, Part 931).

From a regional point of view, the capacity to plan for air quality is a valuable ingredient in defining strategies of regional development. A well understood air emissions inventory and its skillful utilization in air quality modeling can be applied to the region to identify areas suitable for industrial development. A synthesis of this information with demographic, economic, and infrastructure data, can identify the optimum intensity, mix, and location of new industrial development. Currently, these decisions are made by industrial interests with public review having little influence.

Although the state DNR&CD reviews permit applications for new or modified air emissions point sources, its focus is statewide. It is understandable that this

broad focus may not reflect local, social, economic, or physical conditions at the level of detail needed to achieve regional planning objectives. Without regional land use and economic policies based in part on solid air quality planning and technical support, current trends in industrial development may lead to a lack of job diversification and a consumption of the regional air resource so as to preclude future industrial development including onshore facilities needed to support OCS oil and gas activities.

Rogers, Golden & Halpern and Engineers for Energy and the Environment have reviewed the status of air quality planning in the Cape Fear region in order to recommend to the Cape Fear Council of Governments (COG) a planning approach to air quality management. Ideally, this approach should be able to evaluate alternative emissions scenarios in order to select the preferred path for economic development of the region and for the concurrent protection of health and property from deleterious impacts of air pollution.

The focus of our work has been to determine what could be done by Cape Fear COG to implement its own air quality management component for regional planning.

The air quality program would have two purposes. The first would be to apply air quality modeling techniques, using updated point and area emission inventories, to the identification of those areas in the Cape Fear region where new industrial growth could occur with respect to specified emissions, and, correspondingly, to locate areas already impacted by existing industrial growth which new industrial growth should avoid. The second purpose of the program is to examine PSD applications, as they are made to DNR&CD, for modeling assumptions and data inputs to assure that PSD modeling reflects local conditions as accurately as possible. This non-regulatory review function could be quite useful to DNR&CD in its regulatory review and modeling of PSD applications and would be based on a close interagency relationship at the technical level.

A high level of commitment to air quality planning by Cape Fear COG will require the agency to hire a meteorologist with air quality monitoring experience to carry out a four step procedure. Chapters two, three, and four contain our detailed recommendations concerning this procedure which is summarized below.

Establish criteria for the form and content of a Cape Fear Air Emissions Inventory

Chapter 2 states the purpose and expected use of an air emissions inventory for the Cape Fear Region. It discusses the content and spatial resolution that such an inventory should have. It recommends inventory format compatibility with inventories used by other agencies, particularly the state Department of Natural Resources and Community Development (DNR&CD).

Compile the Cape Fear Air Emissions Inventory.

Chapter 3 describes the planning and execution stages of compiling an air emissions inventory including recommendations concerning institutional relationships between the Cape Fear COG and DNR&CD.

Review available air quality models for use in the Cape Fear region.

The first part of Chapter 4 establishes the need for air quality modeling, sets forth seven critical criteria for the selection of the most appropriate model and then describes various air quality models currently in use in air emission determination and regulation.

Select an air quality model for use in the Cape Fear region.

The second part of Chapter 4 evaluates 13 air quality models with respect to the seven criteria established earlier. Of all the models reviewed, the RAM model is selected as the method of choice. Certain modifications to RAM are recommended to bring it closer to satisfying all review criteria. The particular data needs and application of the RAM model are discussed.

In the case that Cape Fear COG does not wish to commit the resources needed to establish an air quality planning capability in house, there are several other less expensive options available to it that will provide the technical capability necessary to protect the region's interests by screening PSD applications as they are made for modeling assumptions and data inputs and by performing special industrial planning studies based on air quality modeling. In Chapter 5,

three alternative approaches to achieving an air quality planning objective are presented and discussed, including the steps, schedule, and budget needed to implement each approach. Recent industrial growth in the Cape Fear region is used to illustrate the need for air quality planning.

The three options for Cape Fear COG to obtain technical input to air quality planning efforts as identified in Chapter 5 are:

1. **Create a Permanent Meteorological Staff**

   Cost

   - salary for meteorologist/air quality specialist: \$28,000-\$35,000/year
   - computer support: \$80,000-100,000/year

   Advantage
   - in-house expertise to create emission inventory, run air quality models for planning purposes and review PSD applications.

   Disadvantage
   - technical capacity with no enforcement authority
   - expensive

2. **Retain an Air Quality Consultant**

   Cost
   - retainer arrangement costs between \$10,000 to \$20,000/year with special studies extra

   Advantage
   - only a small capital expenditure needed to have expert services on call
   - retainer would insure that consultant remained current of air quality situation in region

Disadvantage

- o does not provide in-house capability

3. Obtain Consultant Services When Needed

Cost

- o depends on frequency and size of authorized study

Advantage

- o no expenditure is necessary unless study is needed

Disadvantages

- o quick response to need for study is not possible
- o consultant must rely on State data base

The last chapter of this report is concerned with the likely onshore impacts of outer continental shelf (OCS) oil and gas extraction. Chapter 5 reviews the OCS oil and gas exploration activity in the South Atlantic and discusses the likelihood that OCS-related facilities will locate in the Cape Fear region. Temporary OCS support bases are identified as the only likely facility that may locate in the region. The land, waterfront, and labor requirements of support bases are reviewed and the particular support base experiences in the South Atlantic are described.

2. Criteria for the Development of an Emissions Inventory

The following discussion sets forth criteria for the content and form of an emissions inventory for the Cape Fear area. The criteria are designed to result in a data base amenable to the desired end use, which is atmospheric dispersion modeling. Many of the requirements presented are of a generic nature while others are only applicable to this specific region.

PURPOSE OF INVENTORY

The purpose of creating and maintaining an emissions inventory is to define, in detail, the air contaminant emissions within the Cape Fear COG area as well as those important emissions originating outside the area which may have a significant air quality impact within the area.

EXPECTED USE OF THE INVENTORY

The emissions inventory for the Cape Fear area can be used to define emissions densities and other characteristics vital to the conduct of proper planning for siting of new industrial and energy-related sources of air contaminants. In order to be used for planning purposes the inventory should satisfy the following criteria directly related to end-use:

- The emissions inventory must treat the particular pollutants which will likely be emitted by new energy-related facilities.

- The information obtained must be of sufficient spatial and temporal resolution to permit siting decisions through use of air quality dispersion modeling.

- The inventory information must be installed and maintained on automatic data processing equipment because of its projected use as input to dispersion model(s).

In addition to planning, other uses are normally made of emissions data by enforcement and/or control agencies (i.e., DNR&CD). These uses include design of monitoring programs, development of control programs, development of enforcement strategies, and development of strategies for input to the State Implementation Plan. Since, in the State of North Carolina, these uses are legitimately the function of the DNR&CD or a local air pollution control board authorized and approved by the Environmental Management Commission, they will not be specifically addressed in the design of the emissions inventory for the Cape Fear COG.

Content and Spatial Resolution of Inventory

In light of the fact that the inventory will be used solely to provide input for air quality modeling studies of the COG Region, the following general inventory details for major point sources is envisioned:

1) Name of source

2) Name of source owner (Corporation, Company or Individual)

3) Mailing address of source

4) Name and telephone number of contact at source

5) Year and month of information receipt or update

6) For each emission point at the source:

a) emission rate for each pollutant
b) release height for each pollutant
c) gas temperature
d) volumetric gas flow rate
e) UTM coordinates of emission point
f) temporal variation in source parameters

Suggested methods for obtaining the above information are discussed in Chapter 3.

Of course, the large total number of point sources in the region makes it impractical to obtain detailed information on each. The solution to this problem will rest with the determination of an emissions size cut-off. Those point sources whose emissions are below the cut-off size will be combined into several "area sources." These small point sources will be comprised mainly of space heating sources of SO_2, NO_2, and particulates. In most cases, their emissions must be described through indirect methods such as apportionment of regional fuel consumption on the basis of population density, etc.

Additional area source data will be required to describe emissions from mobile sources. As with space heating emissions, these emissions must also be estimated through indirect methods such as statistics on vehicle miles traveled, vehicle mix, and airport and marine operations. The general content of the inventory for area sources after apportionment to grid zones is expected to be similar to the following:

1) Area source identification number;
2) Coordinate boundaries;
3) Year and month of data receipt or update;
4) Annual emissions density - each pollutant;
5) Temporal emissions variation

The characteristics of the emitters included in the area sources as well as the characteristics of certain of the pollutants generally encountered (especially hydrocarbons) make generation of an accurate area source inventory quite difficult. For example, the majority of hydrocarbon emissions cannot be accounted for

by questionnaire methods. Only a relatively small portion of these emissions are from stationary, discrete combustion sources. The majority arise from bulk storage evaporation, motor vehicle hot soak, cold start and running emissions, filling operations, spray painting and solvent use, natural sources, and numerous other small diffuse sources.

Development of detailed criteria for determination of which pollutants to address in the inventory must proceed from both the standpoint of the type of new industry expected to locate in the region and the standpoint of existing and anticipated federal regulations in terms of ambient standards. The only pollutants which should be included are those which are expected to be both emitted in the Cape Fear area and regulated. These are:

1) Carbon Monoxide
2) Sulfur Dioxide
3) Particulates
4) Nitrogen Oxides
5) Hydrocarbons
6) Lead

The inclusion of pollutants (2) through (6) is for obvious reasons. The inclusion of carbon monoxide at this time is due to uncertainty regarding the pending implementation of the Set II PSD regulations. Omission of oxidants from the list is due to the fact that, while they are a Criteria Pollutant, they are not emitted per se but are rather formed in the atmosphere in a photochemical reaction involving the hydrocarbons. Still other pollutants such as trace elements and radionuclides may well be emitted by the energy industry but these are not expected to have air quality standards attached for at least several years. In addition, trace emissions are quite difficult to quantify without testing every major combustion source and rigorously and repeatedly performing expensive analyses on coal supplied to coal combustion sources.

Of the pollutants recommended for inclusion, lead will probably be the most difficult to quantify followed by hydrocarbons and nitrogen oxides. SO_2 and CO emissions will likely be the most readily determined.

Emissions Data Base Format

The emissions data base developed from the emissions survey and from engineering estimates of emissions will contain vast amounts of data. In addition, the eventual use of the data will be as input to a regional dispersion model designed to project air quality impacts of various planning alternatives. Both the volume of data involved as well as the eventual input to a computerized model dictate that the emissions data base be installed on automatic data processing equipment.

The format of information storage should be designed to facilitate information interchange with other agencies. This is required since it is expected that DNR&CD will provide the major input to the COG inventory. The COG inventory will also require input from DNR&CD or other agencies regarding major sources located outside of COG's area of jurisdiction. Exact determination of final format as well as content, therefore, will depend strongly upon the system employed by DNR&CD. It is our understanding, at this point, that the DNR&CD system is still in development but should be compatible with EPA's National Emissions Data System (NEDS). The air quality model should be designed to use this type of information.

3. Recommended Approach for Initial Compilation of an Emissions Inventory

The approach for compilation of the emissions inventory may be conveniently divided into two phases - Planning and Execution.

PLANNING

The elements of planning which remain before data gathering can begin are strongly dependent on procuring certain vital pieces of information from DNR&CD. In light of the content of the general discussions presented in Chapter 2, an important step for the Cape Fear COG is to establish communications at a technical level with the DNR&CD Wilmington Regional Office. In order to avoid massive duplication of effort and concomitant excessive costs to COG, a good working relationship will have to be developed and maintained with the this agency. The first COG objective should be to obtain the following information:

1) Current and complete emissions inventory for the Cape Fear Region, and, for major sources (greater than 100 t/yr emissions), information for up to 20 miles outside of the geographical boundaries of the region;

2) A detailed description of the policies, procedures and schedules used by DNR&CD to acquire the current emissions data. This is intended to insure consistency of methods between the COG and DNR&CD and to enable evaluation of adequacy of the existing DNR&CD inventory;

3) Copies of all recent PSD applications within or nearby the region. The information contained in these applications will include measured ambient air quality and regional dispersion modeling results.

Once the above-described information is in-hand, initialization and management of the data base can be accomplished. This initialization phase will address items such as which sources will get what type of questionnaire, how will follow-ups be made, what grid system will be used and in which card column or what card will a certain piece of information be punched. The culmination of the planning phase will be the execution of the data collection program.

EXECUTION

Execution of the detailed plan developed as indicated above will probably involve several distinct steps. It is expected that the steps will approximate the following:

1) Obtain field data through questionnaires or engineering surveys;

2) Obtain already-collected data from DNR&CD;

3) Make estimates for mobile sources;

4) Make estimates for small point and area sources;

5) Design, code and implement computer programs to store, retrieve, analyze, and update the emissions data base; and

6) Transfer field and estimated data from hard copy to the computerized file system.

The questionnaires used to elicit information from major sources will have to be carefully designed, striking a balance between information desired and the willingness of industry to obtain and provide that information. Depending on the status of the existing DNR&CD inventory, it is possible that no questionnaires will

ever be mailed by COG. If questionnaires are required, a sample point source questionnaire is provided in Table 3.1.

THE STATUS OF AIR EMISSIONS INVENTORIES

We have reviewed the air emissions inventory for the Cape Fear Region. The information reviewed appears to be generally adequate and could be used in dispersion modeling startup and checkout procedures. However, no area source emissions data were found in the documents reviewed. Furthermore, there appear to be some omissions in the point source inventory for the region. A detailed presentation of findings and recommendations is made in Appendix C.

TABLE 3.1

SAMPLE OF MAJOR STATIONARY COMBUSTION SOURCE QUESTIONAIRE*

Firm Name: ______

Person to Contact Regarding This Questionnaire: ______ Title: ______ Phone: ______

Mailing Address: ______

Plant Address: ______

Nature of Business (Products): ______

Section I - Fuel Use for Generation of Heat, Steam, and Power

Normal Operating Schedule: ______ Hours Per Day: ______ Days Per Month: ______ Weeks Per Year: ______

Seasonal and/or Peak Operating Periods (Specify): ______

Estimate of Percent of Total Fuel Consumed to Provide Space Heat: ______

	A	B	C	D	E	F	G	H	I	J	K	L
				FUEL USE DATA					STACK DATA			
Source No.	Size of Unit Input 10^6 Btu/Yr	Type of Unit	Installation Date	Type of Fuel	Amount Consumed Per Year (Gallons)	Heating Value of Fuel (Btus)	Percent Sulfur	Percent Ash	Height (ft)	Diameter (ft)	Temperature (°F)	Exit Velocity (ft/sec)

EXAMPLE

Section II - Emissions Information

	M	N	O	P	Q	R	S	T	U	V	W	X
	ANNUAL EMISSIONS						METHODS OF EMISSIONS ESTIMATION					
Source No.	SO_2	NO_x	Part.	Lead	VOC	CO	SO_2 Code	NO_x Code	Part. Code	Lead Code	VOC Code	CO Code

*Adapted from EPA APTD 1135 June 1972
The above Questionnaire would be transmitted to the Firm under cover of a letter explaining its purpose, providing detailed instructions for answering each question and providing an engineering contact at COG who can lend assistance to the Respondant.

4. Regional Air Quality Modeling Recommendation

INTRODUCTION

Background and Need for Modeling

The Clean Air Act as amended, requires that the State assure the attainment and maintenance of the National Ambient Air Quality Standards (NAAQS) within its borders. It also requires that "significant deterioration" of air quality from its present status be prevented. These functions are carried out through a plan developed by each state and approved by the Environmental Protection Agency (EPA). The plans are known as State Implementation Plans (SIP).

In the Cape Fear region of North Carolina, state-operated monitoring networks that measure ambient pollutant concentrations have demonstrated that all pollutants are either in compliance with the NAAQS or that insufficient data exist to make a compliance or non-compliance determination. The fact that regional air quality is relatively good has also been confirmed by a measurements program operated by private industry and not related to the state-run network. These measurements were taken by the Brunswick Energy Company. Because of the attainment status of the region, regulatory emphasis and attention is placed on preventing significant deterioration rather than on attainment of the NAAQS.

This emphasis is important since it implies a numerical limit on the amount of pollution ("increment") as measured at ground level which can be generated by sources built or modified subsequent to a given date ("baseline" date). These Prevention of Significant Deterioration (PSD) limits on increases in ambient sulfur dioxide or total suspended particulates concentrations are fairly restrictive

amounting to less than 40% of the NAAQS for a Class II area such as the Cape Fear region. Every new pollution source or modification to a source which increases that source's emissions placed in operation since the baseline date consumes some portion of this increment. Since the increment is defined in terms of ground-level concentrations and sources are not homogeneously distibuted over the region, the amount of increment remaining varies in a spatial sense over the region. Also, since the increments are regulated for more than one averaging period, the percentage of increment remaining may be different for the different averaging periods for the same pollutant. When the available increment has been totally consumed by new or modified sources, no further development which would increase regional emissions will be permitted. For this reason, it is necessary and prudent to effectively manage the remaining increment to assure orderly development commensurate with the socioeconomic goals of the region.

Management of this increment as well as assurance of long-term maintenance of the NAAQS can only be accomplished through use of simulation modeling. It is only through modeling that the vital questions of air quality impact of as-yet unbuilt facilities can be addressed. It is also only through modeling that the desirability of alternative long-term growth scenarios can be assessed. Regional air quality modeling thus becomes one of the indispensible planning tools required to resolve the potential conflicts between economic, energy, and clean air needs and goals of the region.

Model Selection Considerations

Air quality modeling may be defined as the application of a mathematical description of the physical processes involved in transport, dispersion, and chemical and physical modifications of air pollutants to a particular region for the purpose of assessing the ground-level pollutant concentrations to which a population may be exposed. Numerous sets of equations have been programmed for use in digital computers--each set normally referred to as a "model." Since there are wide areas of disagreements among scientists as to the correct mathematical description of the physical processes involved (and even of the physical processes themselves) there is, naturally, an abundance of models all purporting to describe the same physical phenomenon.

This is compounded by the number of physical and chemical processes to be described (e.g., plume rise, plume dispersion, material deposition, photochemical reactions, flow around obstacles, etc.) and the model selection becomes very wide indeed.

Successful choice of a model for application to a particular situation requires a detailed knowledge of emissions characteristics, pollutant characteristics, meteorological characteristics and the behavior of available models in the defined situation. Successful application of the chosen model requires experienced professional judgment confirmed, in the final analysis, by a validation study. Considering the importance of the modeling results to the region, it is imperative that appropriate models be chosen, that proper and adequate input data be prepared, that the model application be properly made, that the results be interpreted with full knowledge of the limitations inherent to the process, and that the entire modeling program be overseen by experienced and competent personnel.

Since the scope of the contract under which this report is written provides only for a recommendation regarding the particular model which is appropriate for use in the Cape Fear region and not for support of model implementation and application, it is crucial that proper staffing internal to the COG be provided for this purpose. As an aid in accomplishing this purpose, Chapter 5 of this report presents a summary of personnel qualifications for a position within the COG out of which the modeling work would be performed. (See Option 1 in Chapter 5.)

The remainder of this chapter is devoted to the selection of the particular air quality model which will meet the anticipated requirements of the Cape Fear COG. Several models are discussed and evaluated and one is recommended for purchase, modification and use. It should be noted, however, that dispersion modeling is a continually evolving field. The normal cycle is that models are developed, come into general use, and are eventually discarded as "improved" models become available. The model recommended in this report should be continually reviewed and updated or replaced when it becomes obsolete. Competent internal staff will be necessary to accomplish this.

MODEL CHARACTERISTICS REQUIRED FOR SUCCESSFUL APPLICATION

Criteria are established for model selection in this section. They are based upon an understanding that the modeling to be performed by the COG will be in support of regional scale planning activities. This assumption is important as it defines the spatial scale of the required model to be regional rather than local. Even though the basic model will be regional in scope, the possible need for evaluation of local impacts of sources will be addressed in the next section where local scale models for vehicular emissions (APRAC) and point sources (ISC) will be described.

Establishment of Selection Criteria

There exist a number of basic model characteristics which must be selected or made compatible with the situation at-hand. The desired characteristics are expressed in this Section as criteria for model selection. It may not be possible to simultaneously satisfy all criteria with any "off the shelf" model. For instance, although not of particular concern in the Cape Fear region, the criteria of EPA acceptability frequently runs counter to the need to address plume impact on elevated terrain. Also, the need to use available meteorological data runs counter to the desirability of addressing spatial changes in the wind field. For these reasons, the selection of a model always represents a compromise between the ideal and reality and frequently represents a compromise between equally practical and realistic, but opposed criteria. Thus, the criteria that follow do not represent the best that science may have to offer since the best would require very detailed input data which are not available. Neither do they lead to the selection of a "cookbook" model since all of the needs of the planning function cannot be satisfied through use of a single "off-the-shelf" model. Rather, the attempt is made to specify an approach which addresses the regional problem at hand, is easily modified or expanded, will operate within the constraints of existing meteorological data, and is practical to apply.

Criteria No. 1: Spatial Characteristics. The modeling package must be capable of addressing the regional scale, on the order to tens of kilometers. It must allow for the specific geographic location of point and area sources throughout the

region at arbitrary points in the model coordinate system. It must be capable of predicting ground-level pollutant concentrations at any desired point within the region.

Criteria No. 2: Temporal Characteristics. The modeling package must address the time scales associated with the averaging periods for the NAAQS. These are 1 hour, 3 hours, 8 hours, 24 hours, 90 days and the annual period. The model package must be capable of evaluating, at a minimum, seasonal variations in emission rates and, preferably, be capable of evaluating weekday-weekend and day-night changes.

Criteria No. 3: Pollutant Types. There are two basic categories of pollutants--those which can be treated as inert gases and those which are reactive or which may be depleted by deposition. The ideal, completely non-reactive, non-depleting pollutant does not exist, but for the space and time scales and purposes involved in this study, SO_2, TSP, CO (carbon monoxide), Pb (lead), and NO_2 (nitrogen dioxide) may be considered to have these conservative properties. Ozone cannot. The modeling package should treat the "inert" pollutants only. Photochemical reactions are <u>not</u> recommended to be treated at this time because of 1) lack of general scientific agreement on proper and practical methods, 2) lack of an EPA-approved photochemical model for general use, and 3) the fact that available oxidant monitoring data shows that ambient levels of this pollutant are well within attainment levels.

Criteria No. 4: Source Handling Capability. The chosen model must be capable of addressing the types of sources found in the Cape Fear region. It must be capable of handling sufficient numbers of non-colocated point and areas sources to realistically describe the emissions characteristics of the region. Each point source should be able to be described by its own unique location, height, diameter, flue gas flow rate or exit velocity, flue gas temperature and emission rate including temporal variations. Each area source should be described by arbitrary location, size, emission rate and effective release height. Without the capability of handling individual point and area sources in this manner, the realism of the model may be severely compromised.

Criteria No. 5: Receptors. A sufficient receptor density should be available to permit "hot spots" to be identified. A sufficient number of receptors should also be available to permit assignment of receptors to air quality monitoring stations for model validation purposes. Receptors which may be arbitrarily assigned to the model coordinate grid are desirable.

Criteria No. 6: Basic Model Type. There are two basic approaches to atmospheric diffusion modeling: gradient transport theory and statistical theory. Gradient transport theory models are most frequently research tools, are not widely used in the operational sense and are not recommended for application to the problem at hand. Statistical models (e.g., "Gaussian" models) are widely used operationally by state and local air pollution agencies as well as the EPA. There are two basic subsets of the Gaussian approach. These are the variable trajectory and constant mean wind approach.

In the variable trajectory approach, spatial variations in the horizontal wind field are accounted for. The variable trajectory model requires detailed meteorological measurements which are not currently available in the Cape Fear region. Given this severe limitation, the variable trajectory model cannot be recommended even though it would probably represent the land-use interface effects better than a constant mean direction model.

In the constant mean wind or "straight line" Gaussian model, a single wind speed and direction is assumed to prevail throughout the region of interest at any given moment. This model is the type that is generally applied in air pollution studies and has been the type of model historically approved by the EPA for use in regional air quality analyses. This model type is recommended for application in the Cape Fear region.

Criteria No. 7: EPA Status. Even within the generally acceptable class of straight line Gaussian models, a very large degree of variation is possible. Literally dozens of basically different models, all belonging to the straight line Gaussian class exist. In addition, there are almost countless variations possible on each of the basic models. Recognizing the need for national uniformity in regulatory practices, Congress required, in the Clean Air Act Amendment of 1977, that EPA adopt a consistent modeling policy. Regulatory positions (written as well

as unwritten) have been developed since that time which are fairly rigid in restricting the amount of modeling latitude allowed. From a regulatory standpoint this is convenient but from a practical standpoint, it makes proper technical treatment of certain situations very difficult. No single model is scientifically applicable everywhere and unique meteorological situations seem to be the rule rather than the exception.

The criteria, therefore, must be that the model be acceptable to the EPA. This may be translated to mean that the chosen model must produce impact predictions which compare favorably with EPA's base model "CRSTER."

RECENT MODEL APPLICATIONS

This section briefly presents and discusses several recent examples of applications of air quality models specifically to the Cape Fear, N.C. region. Each of the cases discussed below was involved with Prevention of Significant Deterioration Permit applications. Although truly regional modeling which would include all regional emissions was not required for any of these applications, examination of the type of modeling employed is instructive because it is current, specific to the region, and provides a good example of modeling which is acceptable to the EPA regional office. Pertinent characteristics of these applications are presented in Table 4.1. The location of the applicants' facilities is shown in Fig. 4.1.

DuPont - Cape Fear Plant

Two DuPont appications for this facility were reviewed. One, an application for a permit to construct and operate a facility for the manufacture of Terephthalic Acid which was dated June 14, 1978, utilized the EPA-developed PTMAX and CRSTER models for determination of carbon monoxide impacts. The other, representing a recent (11/26/79) state and federal application for construction of two 245 x 10^6 Btu/hr input steam generating boilers utilized four separate models, PTMAX, CRSTER, PTMTP, and CDMQC. In both of these cases, PTMAX was applied in a screening procedure to better define the application of the CRSTER model. Non-DuPont sources were not included in the modeling. CDMQC provided results which were judged by the applicant to be unrealistic. This was attributed to

TABLE 4.1

PERTINENT CHARACTERISTICS OF RECENT REGIONAL MODEL APPLICATIONS

Facility	Permitting Action	Models Applied	Meteorological Data Base	Sources Modeled	Background Concentrations
DuPont - Cape Fear Plant - Terephthalic Acid Facility.	State permit to construct and operate and PSD Preconstruction Permit.	PTMAX (for CO and organic compounds).	Internal to Model.	7 stacks.	Not considered.
		CRSTER	Annual Cycle - 1964 Wilmington/Hatteras.	6 stacks.	Considered only "normal" background.
DuPont - Cape Fear Plant - two 245 MM Btu/hr heat input coal-fired boilers.	State permit to construct and operate and PSD Preconstruction Review.	PTMAX	Internal to Model.	8 stacks for SO_2 9 stacks for TSP, NO_x.	No non DuPont.
		CRSTER	Annual Cycle - 1964 Wilmington (Permit Application states "STAR" data but this is believed to be in error).	15 existing stacks for SO_2. 17 existing stacks for TSP, NO_x. 12 future stacks for SO_2. 14 future stacks for TSP, NO_x.	Sources were modeled. Background concentrations for NO_2 only were discussed and were taken from state monitoring data.
		PTMTP	Worst case indentified in CRSTER analysis.	Same as CRSTER "future" case except 2 additional sources considered since sources not colocated in model.	
		CDMQC	Five year STAR data for Wilmington.	16 point sources of SO_2, TSP. 17 point sources NO_2.	
Federal Paper Board Riegelwood - Bark/ Residual Oil Boiler	State preconstruction review and final determination (PSD). Also,,supporting study for modification.	PTMAX (by State of N.C.)	Internal to model.	Not documented in available reports.	Not considered.
		CRS (by EPA)	Not documented.	Not documented in available reports.	Not documented in available reports.
		PTMAX (by State of N.C.)	Worst case identified in CRSTER analysis.	15 point sources including 2 sources at Wright Chemical.	Attempt to handle background by modeling other nearby sources.
		AQDM (by State of N.C.)	Annual Stability - wind rose data. Source and period of record not documented.	19 point sources including sources at Kaiser, Wright Chemical, DuPont.	Attempt to handle background problem by modeling other nearby sources.
		PTMAX (by TRC Consultants)	Internal to model.	1 source (#5 boiler).	Not considered.
		CRSTER (by TRC Consultants)	Annual Cycle - 1964 Wilmington/Charleston.	7 colocated point sources.	Not considered.
		PTMTP (by TRC Consultants)	Worst case identified in CRSTER analysis.	Existing Case - 16 sources. Proposed Case - 15 sources.	Not considered.
		CDMQC (by TRC Consultants)	Wilmington STAR Annual Cycles 1966-1970.	Existing Case - 27 sources. Proposed Case - 26 sources.	Annual background considered through modeling nearby non-applicant sources.
Brunswick Energy Company	PSD Permit Application.	PTMAX	Internal to model.	Not specifically documented - probably 4 point sources.	Not considered.
		CRSTER	Annual Cycle - 1964 Wilmington/Charleston.	4 refinery stacks. 8 non-refinery increment consuming stacks.	Measured.
		VALLEY (modified).	Five year STAR data - Wilmington. Mixing height - 500 m.	4 refinery stacks. 8 non-refinery increment consuming stacks.	Measured.
Diamond Shamrock Chrome Chemicals Plant	PSD Permit Application	CRSTER/MLTCRS	Annual Cycle - 1964 Wilmington/Charleston.	7 Diamond Shamrock sources (includes several combined sources).	Addition of worst case measured background.

*For description of models applied, see Appendix A.

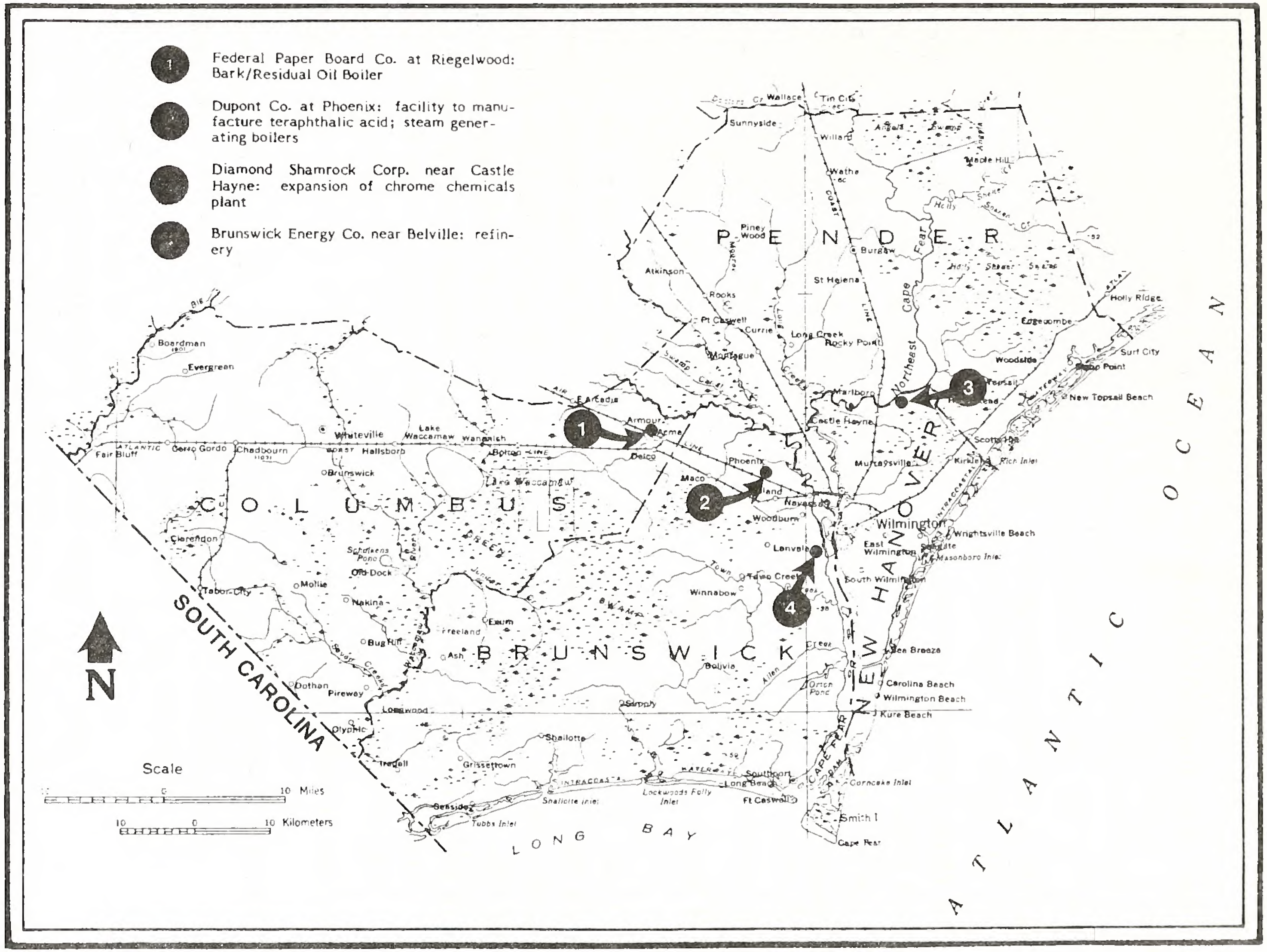


FIGURE 4.1 RECENT PSD APPLICATIONS IN THE CAPE FEAR REGION

the "urban" assumptions in CDMQC being inappropriately applied to a rural location.

Federal Paper Board - Riegelwood

The North Carolina Department of Natural and Economic Resources review of Federal Paper Board's No. 5 Bark/Residual Oil Boiler was dated May 1977. In this pre-construction review, the State agency used the models PTMAX, CRS (predecessor of CRSTER), PTMTP, AQDM, and CDMQC.

Diamond Shamrock - Castle Hayne

A recent PSD permit application for the proposed expansion of the Chrome Chemicals Plant utilized CRSTER and MLTCRS. MLTCRS is Diamond Shamrock's consultant's model patterned closely after CRSTER but able to consider multiple non-colocated sources. EPA has recently released the MPTER model which is capable of fulfilling the same need. This application was dated March 4, 1980.

Brunswick Energy Company - Wilmington

Another recent permitting application (May 30, 1980) applied the EPA-developed models CRSTER, PTMAX, and VALLEY to the problem of predicting ground level concentrations due to the operation of a proposed oil refinery. Again in this case, PTMAX was used as a screening model to determine the proper location of ring distances in the CRSTER model. The application of the VALLEY model to the flat terrain situation in the Cape Fear region, however, is rather unique. VALLEY is a model designed to operate in the rugged, mountainous terrain of the western United States. The rationale for its application to the proposed Brunswick Energy Company facility was that, for annual average impact predictions, it allowed convenient use of a multi-year data base. The meteorological data base used in modeling was from the New Hanover County Airport. Mixing heights were determined from upper air data collected at Charlestown, S.C.

RECOMMENDED MODELING APPROACH

Several potential model and model package candidates have been evaluated. Those models evaluated include all models recommended for use by EPA in their modeling guideline. The models are measured against the requirements set forth earlier in this chapter and a recommended course of modeling action is developed.

Model Selection

Based on criteria No. 6, the model should be selected from the family of straight line Gaussian models. Every model reported to be used by every PSD applicant discussed in the previous section was a straight line Gaussian model. The successful use of this type of model in the Cape Fear region lends weight to the desirability of selecting such a model for regional application.

Models Considered. The air quality dispersion models listed in Table 4.2 were considered as candidates for recommended use by Cape Fear Council of Governments. Their consideration results either from their recent use in a regional permitting action or their mention in the EPA modeling guideline. Two additional models, the Industrial Source Complex Model (ISC) and the MPTER model which were developed too late to be included in EPA's guidelines of 1978 are also considered. All models listed in Table 4.2 are described in Appendix A.

Model Evaluation. Table 4.3 presents a summary of several of the most important characteristics of the fourteen models listed above to facilitate comparison.

Table 4.2. Candidate Air Quality Dispersion Models

Model Name	Source	Reference Number*
Air Quality Display Model (AQDM)	EPA	(1)
APRAC - 1A	EPA	(2)
Climatological Dispersion Model (CDM and CDMQC)	EPA	(3)
RAM (including RAMR)	EPA	(4)
Single Source Model (CRSTER)	EPA	(5)
Multiple Source CRSTER (MLTCRS)	Dames & Moore	(6)
Multiple Source CRSTER (MPTER)	EPA	(7)
Texas Climatological Model (TCM)	Texas Air Control Board	(8)
Texas Episodic Model (TEM)	Texas Air Control Board	(9)
Point Maximum Model (PTMAX)	EPA	(10)
VALLEY	EPA	(11)
PTMTP	EPA	(12)
Industrial Source Complex Model (ISC)	EPA	(13)

*Brief abstracts as numbered are presented for each of these models in Appendix A.

Every one of the models listed in Table 4.3 requires a digital computer facility for implementation. Most are available in the FORTRAN language. Implementation of the models on a computer system requires someone knowledgeable in computer programming since system compatibility changes to the codes are frequently required. Several of the models are relatively large consumers of computer resources, especially those operating on complete annual periods of hourly meteorological data. The computation resource requirement is, in most cases, heavily dependent upon the complexity of the situation being investigated. Numerous point and area sources coupled with many receptors requires substantial resources in certain models, notably RAM.

TABLE 4.3 AIR QUALITY MODEL COMPARISONS

Model	Terrain	Point Sources	Area Sources	Lime Sources	Meteorological Data	Averaging Periods	Horizontal Dispersion
1. AQDM	Not treated.	Arbitrarily located.	Treated by point source approximation.	Not treated.	Annual Stability Wind Rose.	Annual with statistical extrapolation to shorter periods.	22.5° Uniform Distribution (Sector Average).
2. APRAC-1A	Not treated.	Not treated.	Sector area sources. Street canyon sub-model available.	Aggregates to area sources.	Arbitrarily assignment of hourly values.	One hour.	22.5° and 45.0° Sector Average.
3. CDM-CDMQC	Not treated.	Arbitrarily located.	Size must be multiple of user unit.	Not treated.	Annual Stability Wind Rose.	Annual with statistical extrapolation to shorter periods.	22.5° Sector Average.
4. RAM RAMR RAMF RAMFR CUMF RAMBLK RAMQ RAMMET	Not treated.	Up to 250 arbitrarily located point sources accommodated.	Must be squares and multiples of basic user unit. Up to 100 area sources are accommodated.	Not treated.	Hourly wind speed, direction, temperature stability and mixing depth. (Same data format as CRSTER).	One hour and one additional period selected between 2 and 24 hours.	Horizontal off-centerline calculation. Turner curves (rural). McElroy-Pooler curves (urban).
5. CRSTER	Terrain allowed to rise to top of shortest stack.	Up to 19 co-located sources at center of radial grid.	Not treated.	Not treated.	Hourly wind speed, direction, temperature, stability and mixing depth. (Same data format as RAM).	1, 3, 24 hours and annual average. The 24 hr. averages are non-overlapping midnight to midnight.	Horizontal off-centerline calculation Turner curves.
6. MLTCRS	DOCUMENTATION NOT AVAILABLE FOR THIS MODEL - IT IS UNDERSTOOD TO BE VIRTUALLY IDENTICAL TO CRSTER EXCEPT THAT POINT SOURCES NEED NOT BE COLOCATED.						

TABLE 4.3 (Cont'd)

Model	Terrain	Point Sources	Area Sources	Line Sources	Meteorological Data	Averaging Periods	Horizontal Dispersion
7. MPTER	DOCUMENTATION NOT AVAILABLE FOR THIS MODEL - IT IS UNDERSTOOD TO BE VIRTUALLY IDENTICAL TO CRSTER EXCEPT THAT POINT SOURCES NEED NOT BE COLOCATED.						
8. TCM	Not treated.	Arbitrarily located. Unlimited number.	Arbitrary location and square shape.	Not treated.	Annual stability wind rose.	Annual but may be run for shorter periods.	22.5° Sector Average.
9. TEM	Not treated.	Up to 300 arbitrarily located sources.	Up to 200 arbitrarily located sources.	Not treated.	User-supplied scenarios of 3 hours each.	10 minutes, 30 minutes, 1 hour, 3 hours.	Horizontal off-centerline calculation. Turner curves.
10. PTMAX	Not treated.	Single point source.	Not treated.	Not treated.	Generated internally in the program.	One hour.	Lateral centerline concentration.
11. VALLEY	Accommodates any terrain.	Source located at center of radial grid.	Up to 50 point and area sources. Area sources arbitrarily sized and located.	Not treated.	User-input both short-term and annual stability wind roses.	24 hour and annual.	22.5° Sector Average.
12. PTMTP	Not treated.	Up to 25 arbitrarily located point sources.	Not treated.	Not treated.	User-input for up to 24 hrs.	Average provided for number of meteorological hours entered.	Turner curves.
13. ISC	Terrain allowed to rise to top of shortest stack.	Arbitrarily located. Limit depends on computer storage available.	Arbitrarily located. Must be square with uniform N-S and E-W dimensions.	Treated as volume source.	Hourly wind speed, direction, temperature, stability and mixing depth. Accepts same data format as CRSTER.	1, 2, 3, 4, 6, 8, 12 and 24 hrs. (ISCST). Annual (ISCLT).	Horizontal off-centerline computation. Turner curves. Urban option uses destabilization.

TABLE 4.3 (Cont'd)

Vertical Dispersion	Emission Rate	Emission Rate Temporal Variability	Plume Rise	Applicability	Comments
1. Pasquill-Gifford Curves	Single rate for each source.	Not allowed.	Briggs Option.	Urban Access Only.	Generally considered outdated.
2. Modified McElroy-Pooler	Calculated from Daily Traffic Volume.	Hourly emissions are generated internal to the model from Daily Traffic Volume.	Not treated.	Intended for CO predictions for urban areas only.	Requires an extensive traffic survey.
3. Turner Curves	Single rate for each point and area source.	Day/night variation but same variation assumed for all sources.	Not treated for area sources. Briggs neutral/unstable used for point sources.	Urban areas only.	CDMQC is the version containing the statistical model required to determine 1-24 hour average concentrations.
4. Turner Curves (rural) McElroy-Pooler Curves (urban)	Unique, constant rate for each point and area source.	Hourly emissions input on an optional basis.	Briggs for point sources. User input effective height for area sources.	Urban or rural areas.	The RAM User's Manual states "Urban planners may use RAM to determine the effects of new source locations and of control strategies upon short-term air quality."
5. Turner Curves	Unique rate for each of the up to 19 sources.	Monthly rate variation input by user.	Briggs final rise (no intermediate rise).	Urban or rural areas.	This is EPA's "reference" model. Current EPA policy dictates that all other models must successfully compare against. CRSTER.
6. IDENTICAL TO CRSTER					
7.					
8. Turner Curves	Unique, constant rate for each point and area source.	Not allowed.	Briggs neutral/unstable only for point sources.	Basically an urban model.	Model has been reported more accurate when used for point sources than area sources.
9. Turner Curves	Unique emission rate for each point source.	Not allowed.	Briggs plume rise.	Urban or rural.	Model manually applied to determine "worst case" short-term impacts.

TABLE 4.3 (Cont'd)

Vertical Dispersion	Emission Rate	Emission Rate Temporal Variability	Plume Rise	Applicability	Comments
10. Turner Curves	Single emission rate for single point source.	Not allowed.	Briggs plume rise.	Rural.	Basically a "screening model" used to locate and bound maxima.
11. Turner Curves	Single emission rate or area source.	Not allowed.	Briggs plume rise or optimal assignment of fixed plume rise.	Urban or rural; urban lacks terrain.	Model not useful for short-term prediction except for the 24-hour period.
12. Turner Curves	Single emission rate for each source.	Not allowed.	Briggs plume rise.	Predominantly rural areas.	-
13. Turner Curves; urban option uses destabilization.	Unique rate for each point, area and volume source.	Emissions from all or individual sources may be varied as a function of time.	Briggs plume rise.	Urban or rural areas.	Mainly intended for "industrial park" scale but could be applied on a larger scale. Numerous options require a high degree of sophistication in running model.

The choice of an appropriate model for planning purposes for the Cape Fear region will be arrived at through elimination of those models which clearly do not satisfy the established criteria. Those models then remaining will be compared for their merits.

AQDM should not be considered a candidate model since it is outdated and CDM performs essentially the same function using more current formulation. APRAC is eliminated since it is designed and intended for a special purpose use (vehicular emissions only) and cannot treat point sources. CRSTER, MLTCRS, and MPTER cannot be considered since they cannot accommodate area sources, even though CRSTER is EPA's benchmark model for rural applications. PTMTP and PTMAX, generally considered screening models, are also eliminated since they cannot consider area sources. Although we would recommend the use of ISC in evaluating, in detail, single industrial comlexes, should the need ever arise, ISC is intended for use on a spatial scale considerably smaller than the regional scale required here. VALLEY is intended for use mainly in rugged terrain.

These eliminations leave only CDM, RAM, TCM and TEM remaining. TCM and CDM are intended for annual average concentration predictions. RAM and TEM are basically intended for shorter term predictions. Since TCM is primarily designed to be applied to determine "worst case" short-term impacts from a multitude of point and area sources, its usefulness as a regional model where all cases are to be predicted (to generate frequency distributions) is limited. A further limitation of TEM is that the program is capable of handling only three days of meteorological data at a time. As the code is now understood to be written, 122 separate runs would be required to process a year's worth of meteorological data. For the short-term averaging periods, then, RAM is the choice. Regarding annual average concentrations, both CDM and TCM have two serious drawbacks--they are basically urban models (while the region of interest encompasses substantial rural acreage) and they are inadequate to realistically describe variations in source emissions over the annual period. The latter point is more of a problem with TCM than CDM.

Such variations in emissions should be reported in the emissions inventory and should be included in the modeling. Considering these drawbacks and the fact that it would be both logical and convenient to have both short-term and annual

predictions made using the same modeling assumptions, it is recommended that RAM be modified to operate both in a short-term and annual mode. This modification consists mainly of writing a post-processing program capable of reading the partial concentration tape output from RAM and averaging over the appropriate periods. Additional analysis capabilities could be built into this program to allow impacts from selected sources or groups of sources to be examined and frequency distributions constructed. Since some substantial effort will be required to ready RAM to operate in this mode and since RAM is a prodigious consumer of computer resources, the Cape Fear Council of Governments may wish to begin air quality studies with the immediate implementation of CDM to obtain an initial reading on the regional air quality situation. This is further discussed later in this chapter. TCM could also be used in this application but CDM is preferred since it is an EPA model.

Recommended Model. It is recommended that the RAM model be chosen as the basic regional model. It is further recommended that the urban and rural versions of RAM be properly applied to the urban and rural areas of the region of interest. The urban version of RAM is the EPA-approved and recommended model for application in urban areas according to the October, 1980 revision to its air quality model guidelines. Because of the urban/rural classification process prescribed by EPA, it is likely that areas in addition to downtown Wilmington will be classified as urban and appropriately modeled by urban RAM. Rural/urban classification will be a judgment for the personnel actually responsible for implementing the model to make. Surface meteorological data from New Hanover County Airport and upper air data from Charleston, S.C. or Hatteras, N.C. should be used with Charleston being the first choice of the two.

The RAM model consists of a package of computer programs. RAMMET, the meteorological preprocessor, prepares National Weather Service meteorological data for use by the RAM model. It is identical to the preprocessor for the CRSTER model. RAMQ, the source preprocessor, prepares the source data for use by RAM. A post-processing program or series of programs will have to be written by COG staff to perform the proper averaging on the RAM model output tape to obtain average concentrations for time periods of interest other than the single period RAM is capable of averaging. There is an excellent opportunity in preparing this

post-processor to build in analysis tools to enable contributions from chosen sources or classes of sources to be investigated individually.

Because RAM does not completely fulfill the requirements of Criteria 2 and Criteria 7, it is recommended that certain other modifications be made to the model. A professional meteorologist with knowledge and experience in FORTRAN can readily make and verify these changes.

1. The model should be modified (post-processor written) to enable annual averages to be computed using an annual cycle of meteorological data.

2. An option should be created within the model to accommodate emissions changes throughout the annual period. This will affect both RAM and its source pre-processor, RAMQ.

3. The vertical wind speed extrapolation powers should be changed to be identical with the CRSTER model.

4. The portion of the code dealing with the "lidded" case should be modified to limit dispersion in the vertical when stable conditions exist. This is a CRSTER compatibility change.

5. The stack tip downwash currently employed by RAM should be eliminated to assure comparability with CRSTER.

6. RAM should be modified to incorporate the CRSTER terrain treatment.

7. The Briggs plume rise calculations should be altered in terms of the stable rise coefficient and also in terms of plume height above ground before the point of final rise to be compatible with CRSTER.

This model, as any model, should be validated once it has been applied to the region. This is accomplished through comparison of predicted and measured concentrations at the same geographical location. Frequency distributions of both measured and predicted concentrations are most helpful in this comparison. Any systematic model errors detected at this time should be corrected. Large random

departures of predicted from measured values should be investigated to determine the cause and, if possible, correct it.

Use of the RAM model, modified according to the recommendations made here, will satisfy the criteria established earlier in this chapter.

Recommendation of one particular model does not imply that that model should be used to the exclusion of all others. Screening-type models will be required for proper placement of RAM receptors and for decisions regarding point source significance. Also, the recommendation of RAM, based on past experience, will not be valid forever. Dispersion modeling is a rapidly evolving field. Large research efforts are underway to resolve some of the current modeling limitations. Although RAM is relatively modularized and easy to follow so that future changes required by changes in the state-of-the-art will be relatively easy to implement, at some future point the model will simply be obsolete and require replacement. Competent professional judgement is required to continually appraise the scientific status of dispersion modeling and to continually review the merits of maintaining the recommended model.

Data Required for Recommended Model

Source Data.

- Area Sources

  Effective emission height, side lengths, and emission rate are required for each area source. It will require very substantial effort to generate these data for the model. They would include emissions for each appropriate pollutant due to airport operations, space heating, vehicular traffic, and industrial sources too small to warrant being treated as a point source (each below 100 tons/year of a criteria pollutant).

- Point Sources

  For those sources sufficiently significant to treat separately, (over 100 tons/year) stack temperature, exit velocity, exit diameter, and emission rates for each pollutant are required. Information on temporal emissions variations will be required when the model is so modified. The emissions

data should be the most recent available and, ideally, should be no more than two years old.

Meteorological Data. Considering the fact that the terrain of the area is flat and the fact that perturbations on the general flow caused by the proximity of the coastline will have to be ignored due to the current state-of-the-art of approvable dispersion models, meteorological data collected at New Hanover County Airport will suffice for wind, stability and temperature input to the model. Of available National Weather Service stations, this one is deemed the most representative. Data will have to be obtained for that period concurrent with the emissions data as well as concurrent with the validation air quality data used for model validation. This may require special preparation of data at the National Climatic Center (NCC) since observations are required for every hour of the year. Available information indicates that hourly data may not currently be available for certain periods for the Wilmington/New Hanover Airport. The data are required in CD-144 format for input to the preprocessor. Since a long lead-time may be required to obtain these data, the order should be placed months in advance of anticipated need assuming that the required physical tape characteristics and year of validity of the emissions inventory and air quality data are known.

Mixing depth data should be those obtained through radiosonde observations at Charlestown, S.C. These data, known as the Holzworth morning and afternoon mixing depths should be calculated using the New Hanover Airport surface temperature. Hatteras radiosonde data could be used if Charlestown were not available. The Holzworth mixing depths are used as input to the meteorological preprocessor.

Receptor Data. Receptors must be carefully specified. Options are available within the program to allow the model to generate a "honeycomb" receptor array or to automatically generate receptors near major point sources. Alternatively, receptors may be specified by the user. Receptors will have to be judiciously chosen by the meteorologist applying the model. Sufficient receptors will have to be used to generate predictions at all locations of interest (including the ambient air quality monitoring location) and to identify any "hot spots." However, economy will also have to be exercised since the cost of operating the model is almost

directly proportional to the number of receptors used. A proper balance between economy and detail must be struck.

Results Expected from Recommended Model

The recommended model and its post-processor will generate predictions of ground-level ambient air quality for the inert pollutants. These are particulates, SO_2, and CO (when vehicle emissions are treated as area sources). Predictions of NO_x (all oxides of nitrogen) concentrations may also be made and may be interpreted as indicators of actual NO_2 patterns. In a rigorous sense, NO_2 cannot be treated by RAM (or by any other model listed in Table 4-1) since the NO_2 present in the atmosphere is a result of both NO_2 emissions plus the oxidation of NO also emitted from combustion processes. The atmospheric chemistry associated with NO to NO_2 conversion is not adequately understood. For this reason, it is customary (and conservative) to assume that all of the NO_x emitted by a source is NO_2 and to model accordingly with the understanding that the results may be overestimated. The only criteria pollutant the model will be totally incapable of handling will be ozone, as discussed earlier.

Accuracy of dispersion model predictions is generally considered to be within a factor of two of the actual concentrations. If the model validation does not confirm that the model is reasonably accurate, a calibration may be successful in improving the accuracy of the estimates. It should be remembered that the model results can be no more accurate than the input meteorology and source emissions data. Sources not included in the inventory which are present, sources included which are now defunct, or gross errors in emissions or stack data may seriously degrade the modeling. This is not to say that every number input to the model must have a +/-1% accuracy but reasonable care must be taken and emission rates of large sources must be as accurate as possible.

Once the model and its post-processor have been checked-out and validated and the current emissions and meteorological data assembled, the model can be used to generate predictions corresponding to current conditions. Due to the inability to locate receptors at will, the model output will provide a more detailed spatial picture of current air quality characteristics. This can be done for all inert

pollutants for all appropriate averaging times. Graphics, especially isopleths of annual concentrations, helps to promote an understanding of the spatial variation in air quality across the region. This current case becomes the base case against which all proposed or desired emissions changes may be evaluated.

Evaluation of a new major point source may be obtained by simply entering the estimated emissions, grid coordinates, and stack parameters in the RAMQ source pre-processor and then running RAM. The amount of increment remaining may be tracked through modeling of those new sources and emissions changes which have taken place since the "baseline" date. The evaluation of the ambient effects of generic changes in emission parameters such as a change in the permissible sulfur content of fuel oil or the substitution of natural gas for fuel oil on a large scale may also be readily evaluated. This would likely be accomplished through alteration of the area source parameters. Almost any conceivable strategy, as long as it can be translated quantitatively into a change in emissions, can be evaluated for its impact on regional air quality.

Phased Model Implementation

Implementation of RAM and its associated pre-processors and development of a suitable post-processor to provide for averaging and analysis is a relatively complicated task. Since the Council of Governments has not had extensive air quality modeling experience in the past and since it may require a substantial amount of schedule time to make the RAM package operational, it is recommended that the entire UNAMAP modeling series be purchased and some of the simpler models applied first. Especially recommended for this purpose are PTMAX, PTMTP and CDMQC. Experience gained in applying PTMAX and PTMTP to sources in the region will be helpful in the decisions required to locate the RAM receptor fields. Results from the early application of CDMQC should be a good approximation to those to be eventually obtained for the urban portions of the area from RAM. Gross departures of CDMQC results from measured data would indicate that a careful review of the point and area source inventory is required. In addition to obtaining an early indication of regional air quality characteristics, the practical experience gained by the modeling staff will be valuable. This is especially true if the staff generally lacks experience in regional modeling.

5. Alternative Air Quality Planning Structures for the Cape Fear Council of Governments

THE NEED FOR AIR QUALITY PLANNING

There are substantial advantages to a well-understood and utilized air emissions inventory. From a regional planning point of view, it allows for a careful and well planned strategy of regional development, whereby industries can be encouraged or discouraged to locate in an area and hence provides for planning the intensity, mix and location of industries in the region. Although the state DNR&CD is responsible for issuing permits and approvals for new or modified industrial air emission point sources, its focus is at the state level. It is understandable that its broad focus may not always reflect local social, economic, and physical conditions with the sensitivity the region needs to achieve its planning objectives.

Recent PSD applications, reviewed in Chapter 4, point out the need for Cape Fear COG to implement some form of air quality planning or, at a minimum, the capacity to give technical scrutiny to PSD applications for point sources in, or affecting the region. For example, most of these recent PSD applications did not utilize air quality monitoring data to establish baseline conditions but instead created this data based on certain assumptions on air quality. Compounding this possible underestimation of actual conditions is the accepted practice of incorporating the modeling results previous PSD applications as a substitute for monitoring actual air quality. Thus, the anticipated concentrations of air pollutants are based on a pyramid of assumptions as to the actual air quality. This observation is in no way intended as a criticism of the PSD applicants since their modeling efforts used approved EPA models and followed recommended procedures which were reviewed and approved by DNR&CD. The point is that each new applicant is allowed the

opportunity to make a number of assumptions in its favor which may or may not be questioned or challenged.

Ultimately, these shortcomings of monitoring and modeling will be corrected. Until they are, however, the actual capacity of the air to absorb pollutants will decrease with the following possible consequenses:

- The type, scale, and location of industrial development will have been planned and executed by industrial interests with local public review having little influence on any of these important parameters. This could result in an imbalance in the regional economy. It may result in a lack of diversification of jobs and the consumption of the regional "air resource" so as to preclude future industrial development needed to restore economic balance.

- The depletion of the regional air resource may effectively block the construction of onshore support facilities of OCS activities, should a major oil or gas find be made in Lease Sale 56. Although such a find appears unlikely at the present time (see Chapter 6), the region is well advised to keep this option open for at least a decade.

THREE ALTERNATIVES FOR AIR QUALITY PLANNING

There are various levels of involvement that Cape Fear COG can consider with respect to air quality management. The most intense level is for Cape Fear COG to become the local Air Pollution Control Board.

The North Carolina DNR&CD is empowered to delegate its authority as an Air Pollution Control Agency to the Cape Fear COG. Such delegation of state authority to the region would give the COG the power to request, acquire, and compile data for an official regional atmospheric emissions inventory and to review all PSD applications within its jurisdictions. This approach is not recommended from several perspectives: First, such delegation of authority is unlikely from a historical point of view. Second, the level of funding required for a regional

program to quality for such authorization is possibly beyond what CFCOG would want to allocate to such a program.

Even though a designation as a local Air Pollutions Control Board should probably not be sought, based on the above considerations, it would still be highly desirable from a regional planning perspective for Cape Fear COG to have the capabilities to do atmospheric dispersion modeling for planning purposes and to review data inputs and assumptions used in the required modeling efforts of PSD applicants. Chapters 2-4 presented the steps that Cape Fear COG should take to fully implement an in-house capability for regional air quality planning. This approach will require hiring a full time meteorologist/air quality specialist and an allocation of upwards of $100,000 per year for computer-related expenses. However, there are two other approaches requiring a lesser committment of resources that Cape Fear COG can consider. In the discussion that follows we describe each of these three options and list their advantages and disadvantages.

OPTION 1 - PERMANENT METEOROLOGICAL STAFF

This option would allow the Cape Fear COG to retain the services of a competent meteorologist/air quality specialist familiar with atmospheric dispersion modeling techniques for planning purposes. This individual, due to his professional background, should rapidly establish channels of communication with personnel at DNR&CD and obtain access to the latest state's regional air emissions data (also available to the general public). This individual must then have available to him automatic data processing equipment, as well as computer facilities and models, to be able to provide maximum inputs to the planning of the Cape Fear Region.

The Senior Meteorologist/Air Quality Specialist should have as a minimum a bachelor's degree and three years experience in air quality impact analyses or preferably a graduate degree with five years experience in this field. This individual must be able to apply dispersion models to evaluate existing and proposed fuel-burning facilities, a detailed knowledge of Federal and state regulations, previous participation in meteorology/air quality data collection programs, and experience in data processing (FORTRAN) analysis. This individual must also have demonstrated technical verbal and writing skills. It is estimated that a salary offer with a range of $28,000 - 35,000 per year would attract a number of qualified

applicants for the position. Automatic data processing equipment, computer time and programs for this option are estimated to cost between $80,000 - $100,000 per year.

Advantages

a) In-house expertise is available to provide a level of scientific credence to the air quality determinents of Cape Fear COG's regional planning strategies.

b) The staff meteorologist/air quality specialist can initiate activities described in Chapters 2-4 towards the updating and compilation of emissions inventory data, preparation of programs, etc., as soon as he is hired.

c) CFCOG will have the expertise in-house to adapt and fine tune models applicable to the Cape Fear region for planning purposes and to review modeling assumptions and data in-puts used in PSD applications.

Disadvantages

a) Since regional modeling and introduction of new industrial sources are highly politically sensitive issues, and since the findings that the COG's meteorologist may make do not have enforcement authority, this individual has the potential of rapidly becoming dissatisfied with his position.

b) Provisions must be made to keep the meteorologist/air quality specialist abreast of technical developments in his field by attendance at scientific conferences and meetings.

OPTION 2 - OBTAIN THE SERVICES OF A CONSULTANT ON A RETAINER BASIS

This option would allow the Cape Fear to retain the services of a qualified consultant on a standby basis. Under this arrangement, the consultant would be

paid a nominal fee, but be expected to perform the necessary predictive atmospheric analyses in a rapid fashion.

This option allows the Cape Fear COG to have expert consulting services available at a limited cost. If additional work is required above the agreed to terms of the retainment, the consultant would already be familiar with the environs and the available data and therefore be able to perform these studies and analyses promptly.

The typical cost for this type of a retainer arrangement is between $10,000 - $20,000 per year.

Advantages

a) Expert services are available on-call basis.

b) Only a small capital expenditure is required until a specific study is needed; then initiation of study requires only a telephone call or letter.

c) Retainer would pay for gathering available inventory data, as well as developing an initimate familiarity with the local area. Models can be scrutinized and, on a limited basis, evaluated.

Disadvantages

a) Available expertise is not really in-house.

b) Expenditure of monies is made on an on-going basis.

OPTION 3 -OBTAIN THE SERVICES OF A CONSULTANT WHEN NEEDED.

This option would allow the Cape Fear COG to have qualified inputs to the region's development only when needed, therefore, costs would be nominal. However, the study or studies performed would rapidly become outdated and required periodic updating. Long range planning would be difficult at best: since

industries locate or leave the area at will, regional planning efforts would be placed in a post-fact reactive position.

Advantages

a) No expenditures are necessary until study is needed.

b) Selection of a consultant is based on bidding thus assuring qualified, cost-effective work.

c) There is no potential for local bias, since consultant's work is limited.

Disadvantages

a) The need for a study must be recognized early and quickly defined. Monies must then be allocated and a specific RFP issued, all of which delays the quick response that is often necessary.

b) The Consultant would usually require 3-6 weeks to catch up with available information.

c) Work can only be based on the state's available inventory with little, if any, fine tuning of the Cape Fear region per se.

Rogers, Golden & Halpern and Engineers for Energy and the Environment recommend that of the three options presented the second is the one that strikes the best balance between the needs of the region and the planning resources available. Although the first option would give Cape Fear a strong technical support for air quality planning as well as for looking after regional interests in the PSD application process, the high cost of the in-house capability, its potential for interagency friction, and the lack of enforcement authority argue against it. The third option would provide Cape Fear with sound technical advice within the data limitations of the state's emissions inventory, but would, due to the length of time required to define study needs and obtain consultant services to address those

needs, result more in ad hoc reaction to decisions already made by industry and the state than in air quality planning.

The second option is a reasonable intermediate selection. While it relinquishes hands-on control of technical inputs and analyses, it would provide the Cape Fear COG with expert advice from a consultant paid by retainer to be familiar with air emissions inventories, air quality models applicable to the region, and regional meteorology and air quality monitoring efforts. Special planning studies or quick response review studies using this background of region-specific experience and knowledge could be initiated immediately by the consultant upon request by the Cape Fear COG. The consultant could also provide technical assistance to the COG in meetings or correspondence with DNR&CD.

6. An Estimate of the OCS-related Facilities Likely to Locate in the Region and Their Requirements

Based on the assumption of significant commercial finds of oil and gas in the South Atlantic on the Outer Continental Shelf (OCS) the need for a number of onshore facilities could be directed at the Cape Fear Region. Beginning with temporary supply bases during the exploratory phase of development, a significant commercial find would require some or all of the following facilities, depending on the size and proximity of discoveries.

- bases supporting development and production operations
- bases supporting platform and pipeline installation
- platform fabrication yards
- pipe coating yards
- pipelines
- gas separation/dehydration plants
- tank farms
- gas processing and treatment plants
- refineries
- marine terminals

Certain of these needs, such as platform fabrication yards, for example, may be satisfied by existing facilities in the Gulf of Mexico. Summary descriptions of the above facilities are given in Appendix B.

The reality of hydrocarbon explorations to date in the South Atlantic argues persuasively against the need for any of these facilities in the Cape Fear Region over the next 4 to 5 years with the remotely possible exception of a temporary

supply base to service exploratory drilling operations for Lease Sale 56, which will be held in August 1981. The circumstances on which this conclusion is based are discussed in the first part of this chapter. The last half of the chapter will describe the characteristics of temporary supply bases.

THE HISTORY OF OCS ACTIVITY IN THE SOUTH ATLANTIC

The continental margin of the South Atlantic is considered to be a likely petroleum province. The areas most promising according to petroleum geologists are the continental shelf, the Blake Plateau, and the continental slope. The relationship of these features to the coastal areas of North Carolina, South Carolina, Georgia, and Florida is shown in Fig. 6.1.

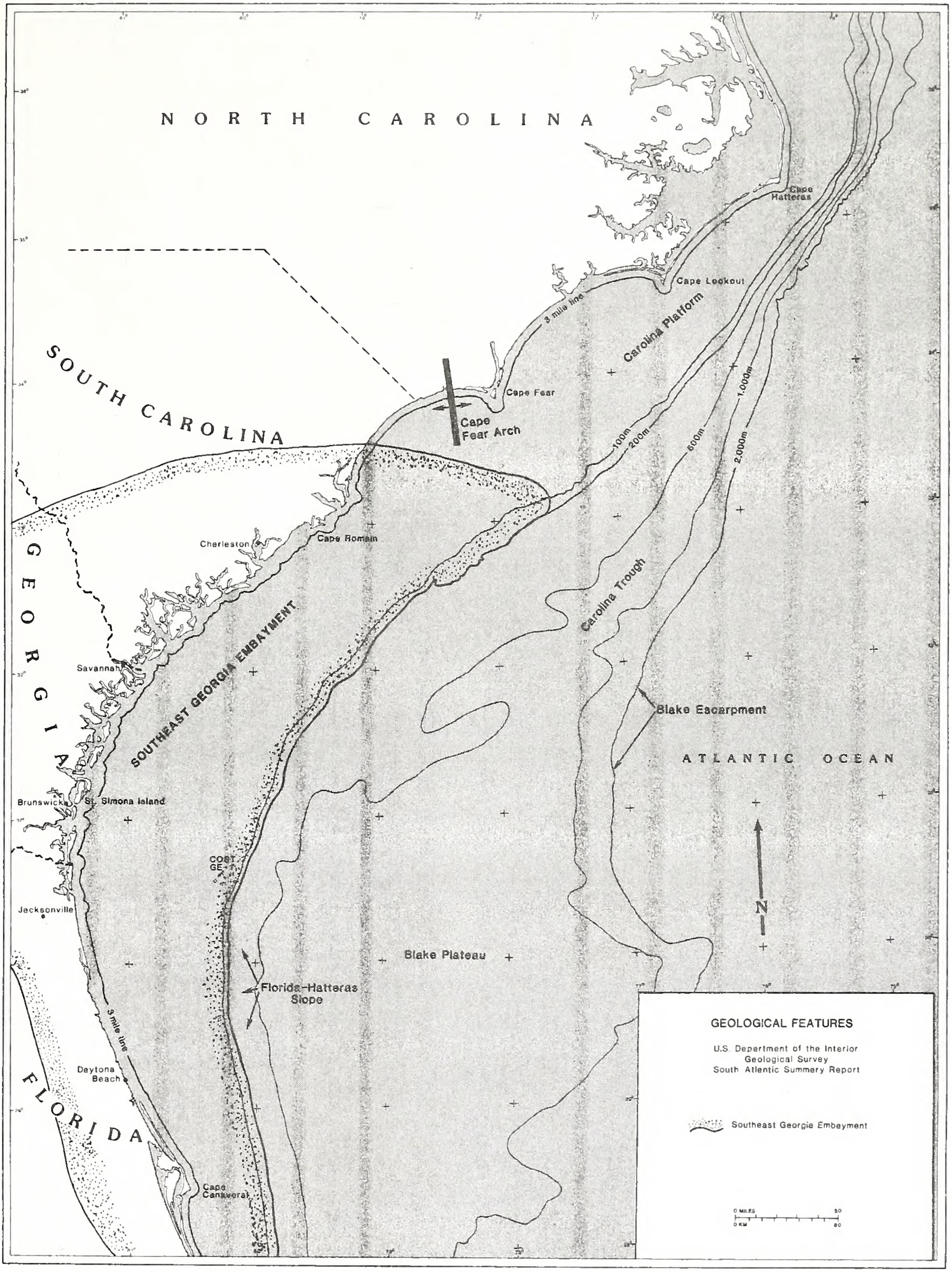
Lease Sale 43

After geophysical surveys were initiated in 1960, a deep Continental Offshore Stratigraphic Test (COST) well was drilled by a group of 25 oil companies under USGS permit in 1977. The purpose of this well was to develop preliminary estimates of the area's petroleum potential in order that the companies could prepare bids for Lease Sale 43. The tracts off the coast of Georgia and Florida that were leased on March 28, 1978, as a result of estimates based on the COST well are shown in Fig. 6.2.

Onshore support for the drilling of exploratory wells for Lease Sale 43 was provided at Savannah, Brunswick, and St. Simon's Island, Georgia. The Savannah base was used for the first wells drilled by Tenneco. Later Exxon, Getty, and Transco used Brunswick as a support base where the city had just completed construction of a 1.2 million dollar OCS support facility. All companies used St. Simon's Island as a helicopter base during the drilling of exploratory wells for Lease Sale 43.

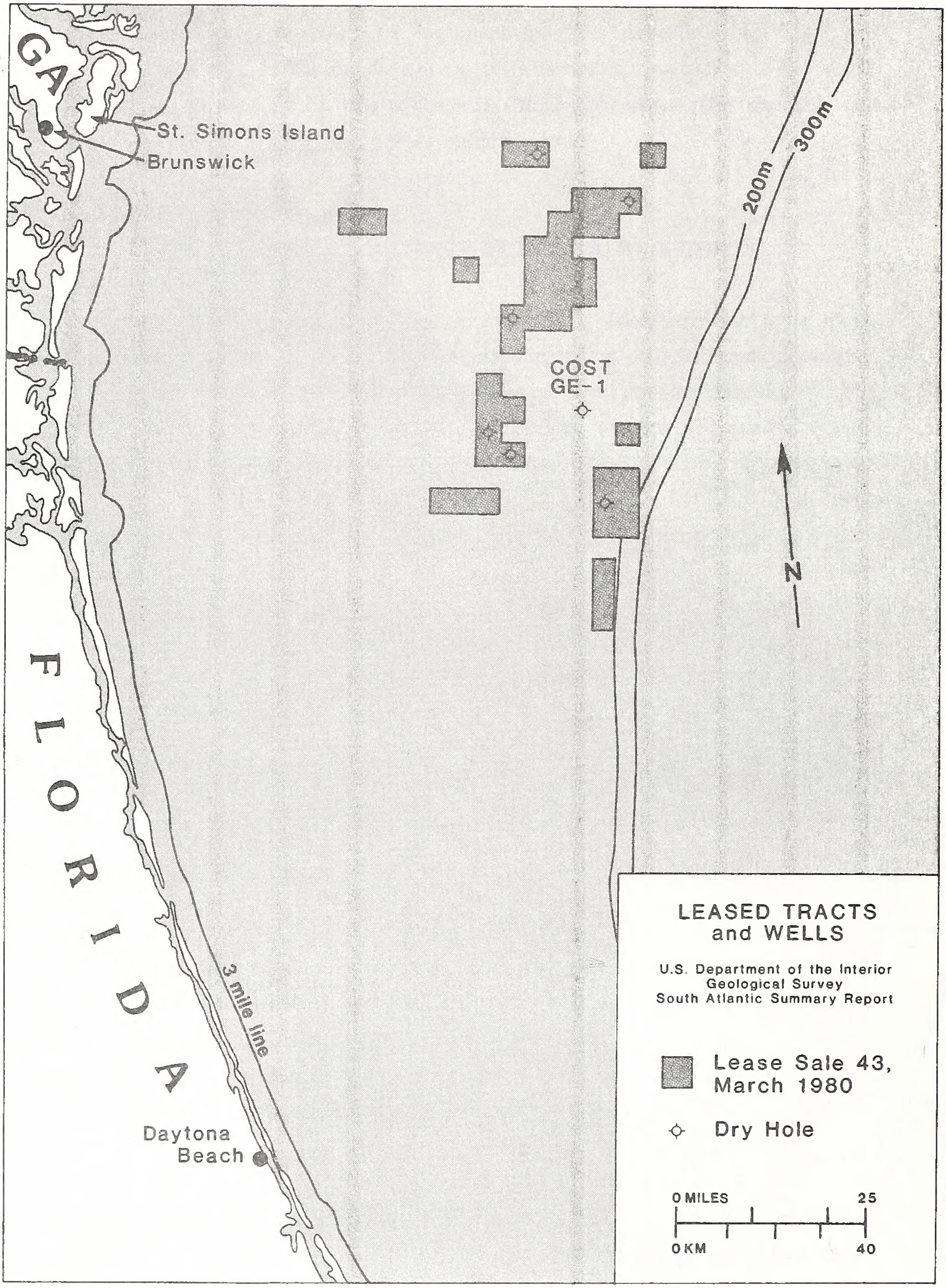
Between May 1979 and January 1980, six exploratory wells were drilled by four oil companies into Lease Sale 43 tracts. All six wells were classified as dry holes which so far has discouraged further drilling in Lease Sale 43 tracts.

FIG. 6.1. Geologic Features of the South Atlantic Region



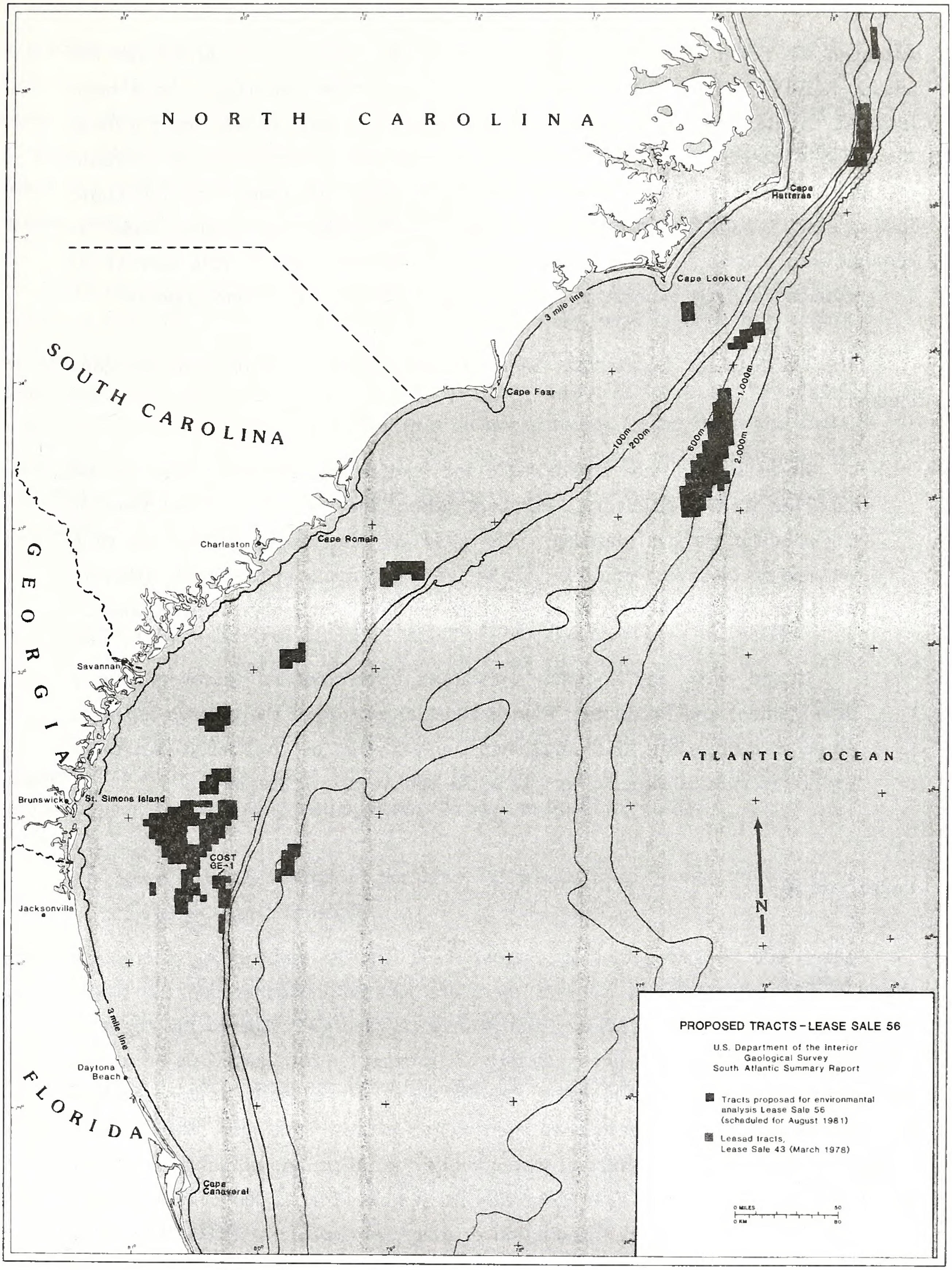
(Adapted from Jacobson, 1980, by Rogers, Golden & Halpern: see Jackson, 1980.)

FIG. 6.2. Lease Sale 43, Leased Tracts and Wells



SOURCE: Jackson, 1980.

FIG. 6.3. Tracts Proposed for Lease in Lease Sale 56



SOURCE: Jackson, 1980.

Although the negative results from these test wells are not conclusive for the entire South Atlantic, initial hydrocarbon estimates for the region have been lowered. At the time the last exploratory well in Lease Sale 43 was being drilled, the USGS released the risked estimates of undiscovered, economically recoverable oil and gas resources for all 43 tracts: 7.9 million barrels of oil and 48 billion cubic feet of gas. These estimates are below commercially producible amounts based on geologic information from the 6 exploratory wells and the COST well, current oil and gas prices, and the expense of constructing an offshore-to-onshore pipeline.

The USGS Outer Continental Shelf Oil and Gas Information Program concludes:

> Reserve estimates approximate the cumulative production that can be expected from a discovery. For this reason, they provide a foundation for site-specific onshore planning. The entry for reserves is zero at this time because no discovery of oil or gas has yet been made in the South Atlantic. However, not all prospective areas in the South Atlantic have been explored.
>
> If and when any company announces a commercial discovery and a Development and Production Plan is filed, a revision of the reserve estimate would be appropriate. But until such time, it must be considered that there are no reserves of either oil or gas in the South Atlantic Region.

Lease Sale 56

Lease Sale 56 is scheduled for August 1981. The 286 tracts being offered are shown in Fig. 6.3. About a third of them are located in and around the tracts leased for Lease Sale 43 offshore from Brunswick, Georgia. Due to the negative findings from Lease Sale 43, not much interest is expected for Lease Sale 56 in this area. Other tracts offered in Lease Sale 56 are scattered north of Brunswick in eight locations. No COST wells have been drilled in these locations. The southern ones are in less than 100 meters of water, while the others and notably the largest one, 100 miles ESE of Cape Fear, generally lie in water that is 600 to 2000 meters deep. There are not yet any production drilling rigs capable of extracting oil at these depths, although there are exploratory rigs that are. However, the latter are

in greater demand in areas of the world with more favorable geologic characteristics; a several year wait for rigs to be available is not unlikely. The oil industry ranks the Blake Plateau (see Fig. 6.1) as 13th of 22 OCS areas worldwide thought to have significant oil reserves. The USGS ranks the Southeast Georgia Embankment and Blake Plateau as 15th and 17th respectively out of 22 potential OCS areas. Lease Sale 56 is not expected to be a particularly successful sale.

The now inactive support bases at Brunswick and St. Simon's Island, Georgia, could be reactivated to supply Lease Sale 56 activities when and if they occur, although the long 350-mile 2-day trip to the Cape Fear cluster of tracts may very likely argue in favor of establishing a much closer base. If tracts in the largest contiguous cluster of tracts in Lease Sale 56 are actually leased, then the Cape Fear or Cape Lookout regions, being the closest landfalls, could plausibly be selected as the site for supply boat and helicopter service support bases sometime in the next 2 to 3 years.

DESCRIPTION OF THE REQUIREMENTS OF OCS-RELATED FACILITIES LIKELY TO LOCATE IN THE REGION

In the previous section the possible need for a temporary supply base to support OCS activity for Lease Sale 56 was identified. Before such a supply base is actually built, the following assumptions will have to become reality.

- Lease Sale 56 results in the lease of tracts from among the northern cluster of tracts offered.
- Exploratory drilling rigs capable of drilling at the depths of the lease tracts are available within the lease period.
- The leased tracts are located closer to Cape Fear than other potential support areas.
- Cape Fear has suitable waterfront land available where a supply base could locate.

General Characteristics of Temporary Support Bases for OCS Exploration

Support bases for OCS exploratory drilling activities are of two kinds: one as a staging and storage area for supply boat-transported materials needed for drilling activities; the other is a base for helicopters that ferry drilling rig crews back and forth to the rig. These two types of bases need not be located at the same site. The supply boats carry drill pipe, casing, hardware, drilling mud, cement, food, fuel, water, and other equipment. The onshore support base for supply boats requires dock space, warehouse space, land for open storage, and access by road and rail. In the South Atlantic, supply boats have been 48 to 60 meters long, 12.5 meters wide and draw up to 5 meters when loaded. A more detailed presentation of the land, waterfront, and labor requirements and potential air emissions of a temporary supply base is given below.

Land. A minimum of 2 hectares is required per rig serviced for a support base including helicopter services, although there is some economy of scale for space if more than one rig is serviced by a supply base. The land area per rig can be broken down as shown in Table 6.1. The site must have either road or rail access, preferably both to allow efficient transmission of materials needed in the drilling operation including freshwater, drilling mud, cement, tubular goods, fuel for transportation and drilling, food, tools, and parts.

Waterfront. The supply base must be located on the waterfront in an all weather harbor. Approximately 60 meters of marginal wharf are required per drilling rig in order to load and unload supply boats. The water depth in approach channels and at dockside must be at least 4.6 meters at low tide.

TABLE 6.1 LAND REQUIREMENTS FOR A TEMPORARY SUPPLY BASE[1]

Function	Approximate Area per Rig Serviced (Hectares)
Warehousing	0.2
Open storage	0.4
Helipad	0.4
Office and communications	0.02
Parking for employees	0.2
Other land (roads, rail access, and function separation)	0.8

[1] From NERBC Factbook, Nov. 1976, p. 113.

Labor. If available, the local labor force can satisfy about 30 to 35 of the 45 onshore jobs created per drilling rig at a temporary support base. The average annual salary of these jobs is $17,000. The support base job categories are wharf and warehouse crew, helicopter crew, and supply boat crew. Most of the offshore jobs are filled by people brought into the area by the oil companies or their contractors, although these companies are usually willing to hire locally whenever possible.

Air Emissions. Support bases are accompanied by air emissions due to the evaporation of fuel during transfer or storage and to its combustion by machinery and vehicles operating at the site. Evaporation from fuel storage tanks depends on the tank type (fixed roof, floating roof, or variable vapor space), its size, color and condition, and its usage patterns. Fuel vapor losses from floating roof type tanks eliminate breathing losses although they are subject to losses due to improper sealing between the floating roof and the tank walls. For fixed roof tanks vapor recovery methods can reduce evaporative losses by 90 to 95%. Loading and unloading supply boats and tank cars, and supply boats in transit, are activities that release significant amounts of unburned hydrocarbons to the atmosphere. Carbon monoxide, nitrogen oxides and hydrocarbons are released by trucks, boats, trains and helicopters in and around the supply base as combustion emissions. Other air

emissions can arise from dry-pumped cement and drilling mud during transfer operations in case there is spillage or the blowout of a hose.

Supply Base Experience in the South Atlantic

In order to give some idea of what to expect if Lease Sale 56 onshore exploratory support were to locate in Cape Fear, it is instructive to describe the salient characteristics of the support bases in coastal Georgia that serviced drilling activities for Lease Sale 43.

Savannah. Saylor Marine Corporation owned a 2.8 hectare property with a 152-meter frontage on the Savannah River and enough dock and warehouse space to serve as a temporary support base for the early Tenneco OCS exploratory operations in May 1979. The Saylor marina was also served by rail and adequate highway access.

Brunswick. The city of Brunswick, in anticipation of exploratory drilling, built a 1.2 million dollar support base. Coastal Energy Impact Program (CEIP) funds guaranteed the financing of construction. This facility was specifically designed to service the particular access, storage, and transfering needs of the OCS drilling activities. The facility provides warehousing for dry storage, open storage for pipe and pipe casing, fuel storage tanks, drilling mud containers, dock space for loading and unloading, and berthage for work boats. The site also includes loading cranes and office space for operation management. The city and local business interests actively sought out oil companies to use this support base.

Getty, Tenneco, and Exxon utilized the Brunswick support base. Exxon leased additional office space (350 square meters) offsite in Brunswick. Global Marine, Inc., the company that leased the drilling rig to Exxon, also rented office space in Brunswick.

St. Simon's Island. All drilling operations for Lease Sale 43 were serviced by helicopters that used Malcolm McKinnon Airport on St. Simon's Island as a base to ferry work crews. This existing facility met all the needs of the operations, including hanger space, warehouse, helicopter pad (less than 0.5 hectares) and office space.

In addition to oil industry use of St. Simon's Island, the USGS established a temporary field office there as a base from which to monitor OCS drilling activities.

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APPENDIX A. ABSTRACTS OF AIR QUALITY DISPERSION MODELS*

1. **AQDM**

<u>Abstract:</u> AQDM is a climatological steady state Gaussian plume model that estimates annual arithmetic average sulfur dioxide and particulate concentrations at ground level in urban areas. A statistical model based on Larsen is used to transform the average concentration data from a limited number of receptors into expected geometric mean and maximum concentration values for several different averaging times.

2. **APRAC-1A**

<u>Abstract:</u> APRAC is a model which computes hourly average carbon monoxide concentrations for any urban location. The model calculates contributions from dispersion on various scales: extraurban, mainly from sources upwind of the city of interest; intraurban, from freeway, arterial, and feeder street sources; and local, from dispersion within a street canyon. APRAC requires an extensive traffic inventory for the city of interest.

3. **CDM and CDMQC**

<u>Abstract:</u> CDM is a climatological steady-state Gaussian plume model for determining long-term (seasonal or annual) arithmetic average pollutant concentrations at any ground-level receptor in an urban area. An expanded version (CDMQC) includes a statistical model based on Larsen to transform the average concentration data from a limited number of receptors into expected geometric mean and maximum concentration values for several different averaging times.

4. **RAM and RAMR**

<u>Abstract:</u> RAM is a steady state Gaussian plume model for estimating concentrations of relatively stable pollutants for averaging times from an hour to a day from point and area sources. Level or gently rolling terrain is assumed. Calculations are performed for each hour. Both rural and urban versions are available.

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*Air quality dispersion models are made available by the Environmental Applications Branch. In addition to having executable programs on EPA's UNIVAC 1110 at Research Triangle Park, NC, a tape having FORTRAN source programs has been placed with NTIS (National Technical Information Service). U.S. Department of Commerce, Springfield, VA 22161. The current tape is called: UNAMAP (Version 3). Its accession number is PB-277-193. There are eleven dispersion models contained on the tape.

5. **Single Source CRSTER**

Abstract: CRSTER is a steady state Gaussian plume technique applicable to both rural and urban areas in uneven terrain. The purpose of the technique is: (1) to determine the maximum concentrations, for certain averaging times between 1-hour and 24-hours, over a one year period due to a single point source of up to 19 stacks, (2) to determine the meteorological conditions which cause the maximum concentrations, and (3) to store concentration information useful in calculating frequency distributions for various averaging times. The concentration for each hour of the year is calculated and midnight - to - midnight averages are determined for each 24-hour period.

6. **Multiple Source CRSTER (MLTCRS)**

Similar to 5 above but for multiple sources.

7. **Multiple Source CRSTER**

Similar to 5 above, but applicable to multiple sources up to 19 colocated elevated stack emissions.

8. **Texas Climatological Model**

Abstract: The Texas Episodic Model (TEM) is a short-term (10 minute to 24 hour averaging time) Gaussian Plume Model for prediction of concentrations of nonreactive pollutants due to up to 3400 elevated point sources and up to 200 area sources. Concentrations are calculate for 1 to 24 scenarios of meteorological conditions, averaging time, and mixing height.

10. **PTMAX**

Abstract: Performs an analysis of the maximum short-term concentrations from a single point source as a function of stability and wind speed. The final plume height is used for each computation.

11. **Valley**

Abstract: This algorithm is a steady-state, univariate Gaussian plume dispersion algorithm designed for estimating either 24-hour or annual concentrations resulting from emissions from up to 50 (total) point and area sources. Calculations of ground-level pollutant concentrations are made for each frequency designed in an array defined by six stabilities, 16 wind directions, and six wind speeds for 112 program-designed receptor sites on a radial grid of variable scale. Empirical dispersion coefficients are used and include adjustments for plume rise and limited mixing. Plume height is adjusted according to terrain elevations and stability classes.

12. **PTMTP**

Abstract: Estimates for a number of arbitrarily located receptor points at or above ground-level, the concentration from a number of point sources. Plume rise is determined for each source. Downwind and crosswind distances are determined for each source-receptor pair. Concentrations at a receptor from various sources are assumed additive. Hourly meteorological data are used; both hourly concentrations and averages over any averaging time from one to 24 hours can be obtained.

13. **ICS**

Abstract: The Industrial Source Complex dispersion models (ISC) are intended to address complicated air quality impact analysis problems that cannot be adequately handled by the existing, generally available computerized models. The ISC short-term model (ISCST) is an extended version of the CRSTER model. The ISC long-term model (ISCLT) is a sector-averaged model that extends and combines basic features of AQDM and CDM. ISC accepts three source types - stack, area, and volume. The steady-state Gaussian plume equation for a continuous source is used to calculate groud-level concentrations for stack and volume sources. Area source contributions are computed based on the equation for a continuous and finite crosswind lime source. The generalized Briggs plume rise equations, including momentum, are used. Plume rise is a function of downwind distance. Procedures suggested by Huber and Snyder are used to evaluate the effects of structure - induces aerodynamic wakes and eddies on plume dispersion. The model has rural and urban options. Wind speeds are adjusted from measurement height to emission height. Terrain is accounted for by reducing the plume centerline height by the elevation difference between source and receptor. The model is also capable of accounting for the effects of gravitational settling and dry deposition. The ISC Model computer programs are written in FORTRAN IV and require approximately 65,000 words of storage.

APPENDIX B. DESCRIPTIONS OF OCS-RELATED ONSHORE FACILITIES[1]

Bases Supporting Development and Production Operations

Support bases set up during the development or production phases of OCS activities serve basically the same function as temporary support bases--i.e. transferring materials and workers between shore and the offshore facilities on a twenty-four hour seven-day-a-week basis--but on a larger scale. The main difference is in the physical size of the base and the intensity of support services. Facilities required in addition to those found on an exploration support base may include

- engineering facilities,
- food procurement and cold storage facilities,
- service base store,
- facilities for arrangement of laundry services,
- secretarial facilities,
- conference rooms,
- car rental facilities,
- security service facilities, and
- explosives storage.

Permanent support bases may be set up by the oil companies involved or by service companies. The land will be either purchased or leased on a long-term basis. In some cases a decision will be made to simply expand the existing temporary support base. The company operating the base may opt to bring in other companies such as cement companies, caterers, and other specialist suppliers as tenants, or may act as an agent for ordering and distributing supplies.

Bases Supporting Platform and Pipeline Installation

Very similar to the support bases set up during the exploratory phase are the bases set up to support installation of platforms and pipelines for OCS development. Unless a large volume of work over an extended period of time is anticipated, these bases will be set up on a short-term basis. Their main requirement is waterfront warehouse space and service and maintenance facilities for vessels and barges. The companies involved in platform or pipeline installation generally set up their own support bases. One base generally has the capacity to support several operations at once.

If there is no space available at the oil company's service base, an attempt is made to locate these bases in the same area or even the same port as the service base. A site with an area of five acres is generally adequate for installation of a pipeline or up to four platforms. The pipe for pipeline operations usually is not stored at the base, but rather is shipped directly from the pipe coating yard to the offshore site. For both platform and pipeline operations a minimum of 200 feet of marginal wharf is required. An additional 200 feet is preferable for each "spread" (fleet of ships) supporting each platform or pipeline installation operation. Road and/or rail access to the base is essential for transporting materials into the base.

[1] Facility descriptions from New Jersey Energy Development Study (1981) prepared by Rogers, Golden & Halpern for NJ DEP/Division of Coastal Resources.

Platform Fabrication Yards

Platform fabrication yards are facilities at which development and production platforms are constructed. Platforms are either made of steel and anchored to the seabed by pilings (or cables), or made of concrete and held in place by their own weight.

Steel platforms consist of two components--a jacket, or base, made of welded tubular steel members, and a deck supporting modular wellhead, processing equipment, and living quarters. After assembly, the jacket is towed to its offshore destination. The deck is towed out separately from the jacket, either preassembled or in sections, and installed on the jacket once it is secured in place.

Concrete platforms are hollow concrete bases with from one to four slip-formed towers on which the deck structure is installed in protected waters near shore. The assembled unit is towed to the offshore drilling site and lowered into place. Because of the great depth of water needed for concrete platform assembly (480-800 feet) and towing (128 feet), steel platforms will probably be used in the Mid-Atlantic region.

Two other kinds of platforms, still in experimental stages, are the tension leg platform and the guyed tower platform.

Steel platform fabrication yards generally are large sites on level land that has a good load bearing capacity. For fabricating steel platforms a waterfront location with marginal wharfs, uncrowded access to the sea, and water depths of at least 20 to 40 feet, preferably 35 to 50 feet, are required. Steel platform fabrication yards often occupy sites on the order of 1000 acres; however, a site as small as 50 acres may be adequate in some instances. The size mainly depends on the number of platforms constructed annually and the number of platform components constructed on the site.

About 60% of the land at a steel platform fabrication yard is occupied by storage and support uses (warehouse buildings, layout buildings, machine shop, welding areas, sandblasting and parking areas, plate and pipe shops, and administrative offices), and 40% is occupied by fabrication uses (jacket and pile fabrication areas, deck assembly areas, and areas for fabrication of modules such as living quarters, drilling rigs, production facilities, wellhead, water injection modules, and helipads).

Pipe Coating Yards

Pipe coating yards supporting OCS operations are faciities that prepare pipe joints for transporting oil and gas from offshore. The coatings consist of a mastic coating to prevent corrosion and a concrete coating to overcome buoyancy and protect the pipeline from mechanical damage. Pipe is delivered to the yard from the steel mill by barge or railroad gondola car. The pipe joints are unloaded by mobile cranes and placed in open storage. Prior to coating, the pipe joints are cleaned and prepped, which includes shot blasting to stipple the surface to provide good bonding surface. The pipe is primed with an asphalt and petroleum thinner, then coated with a bituminous mastic compound, which is applied with an extrusion die appicator. In order to shrink the coating and produce a tight seal, the inside of the pipe is sprayed with water. After cooling is accomplished, a whitewash of

hydrated lime is applied and allowed to harden. The pipe is trimmed, inspected and any gaps in the coating are patched. The mastic coated pipe is stacked on two sand berms for several days, undergoes a final inspection, then goes on to the concrete coating station. In this process, a coating of high density (140-190 lbs/cu.ft.) concrete is applied with throwing belts or rollers as the pipes rotate past at a rate of 6000 feet/min. Wire mesh is rolled into the coating simultaneously. After the concrete coating is applied, each joint is weighed, the ends are cleaned, and the wire mesh is trimmed. A curing membrane is sprayed over the concrete coating and the pipe is set out to cure for four days prior to stacking. After this initial curing period, the coated pipe can be stacked for a 28-day curing period, after which the pipe is loaded out on supply barges which will transport the pipe to the lay barges that install the pipelines.

Pipe coating yards may be either portable (temporary) or permanent. Portable plants, also called "railhead operations," are set up for short-term contract work that can be accomplished in one season, and generally use rented equipment and are located on leased land. A temporary facility may be converted to a permanent facility if the projected volume of work justifies the investment.

The size of pipe coating yards reflects the need to devote large areas to open storage. Generally pipe coating yards fall in the range of 75-100 acres, although they may be as large as 500 acres, or as small as 30 acres. About 95% of this land is in open storage, both for pipe and for stock piling materials such as iron ore, sand, fiberglass wrapping material, lime, and wire mesh, while the remainder houses the coating buildings and load out operations. About two acres is given over to the contractor's inspection personnel and their equipment.

Pipe coating yards must be situated on a waterfront with a marginal wharf in order to accommodate delivery of materials by barge and loading of lay barges. A 750-foot wharf will allow two barges to be loaded simultaneously. A channel depth of 20-30 feet is needed to accommodate 30,000-ton ore-delivery barges. Easy access to a railroad is also desirable for delivery of materials.

Pipelines

The pipelines considered in this study include onland oil and gas pipelines and offshore oil and gas pipelines to the three-mile limit.

The oil and gas transportation strategy chosen for a given production area depends on a number of factors such as

- total oil and gas reserves,
- distribution of reserves,
- rate of production,
- distance and route from production area to delivery point,
- water depth,
- topography, on sea or land,
- geology and soils,
- types of crossings (water bodies, road, railroad),
- land use,
- existing rights-of-way,
- environmental concerns,
- capital investment required,

- operating costs, and
- value of oil and gas.

Natural gas generally is sold to the gas transmission company at the platform and the gas company builds the pipeline from the platform to its transmission line. Normally, when the oil find is large enough to justify the high cost, a pipeline is constructed to transport offshore oil to onshore processing and distribution facilities. During oil pipeline construction or in commercially marginal or inaccessible fields, oil may be brought ashore by barges and tankers.

A single main pipeline may directly link the platform and onshore facilities or smaller gathering lines may transport the products of several platforms to a larger, centrally located transmission line for transport to shore. When several companies are operating in the same general area, they are required by Federal regulations to build a common carrier pipeline that transports their combined products. Careful metering of the throughput at both ends ensures that each company receives its share.

A marine pipeline system, whether for oil or gas, consists of a pressure source (if well pressure is not sufficient), gathering lines (if used), a main pipeline, intermediate pressure booster stations (if necessary), a landfall, and an onshore destination.

Marine pipeline routes, landfalls, and onland pipeline routes are surveyed once a production field is delineated. This survey process may take several years to accomplish. Usually the marine pipeline is routed to the nearest point of land because of the huge expense of building marine pipelines. However, other factors, such as earthquake fault zones, bottom topography and other obstructions, excessive depths, bottom currents, shifting sand dunes, environmental sensitivity, marine activity in the area, and proximity to existing or potential onshore facility sites may result in taking a longer route. There are three commonly used methods of laying a pipeline:

- lay barge method,
- reel barge method, and
- pull method.

Often marine pipelines are buried in order to provide stability and protect them from mechanical damage. The U.S. Department of the Interior requires burial of all pipelines in water less than 200 feet deep. After the pipeline is in place, a bury barge is used to dig a trench beneath it. High capacity pumps furnish water at high pressure to a jet sled that straddles the pipeline, flushing out the sea floor beneath the pipe. The pipeline becomes buried as the mud and sand settle to the bottom or are washed over the pipe by currents. Three other methods--mechanical cutting, fluidization, and plowing--also may be used to bury the pipeline.

Once the pipeline location is decided on and arrangements are made for producing and coating the pipe sections (see Pipe Coating Yards). The pipeline installation can proceed.

The landfall is the section between the points where lay barges and conventional onland pipe laying equipment can operate. The selection of a landfall site involves minimizing the length of the more costly marine section, considering

the onland pipeline route, and accommodating the siting of associated onshore facilities such as gas processing plants.

Special pipelaying methods are required in the landfall area, the method used depending on whether the pipeline crosses a wetland area, a barrier island beach-dune system, or a beach-upland area. For wetland crossings either the "push" or "shove" technique or the flotation method can be used, depending on the ability of the wetland to support the dredging equipment. In a barrier island beach-dune system a trench is opened from the shore side out to a water depth in which a lay barge can operate. In the beach-upland area (high energy, open coast beach areas where the shoreline is receding) the pipeline must be buried deeply to ensure that erosion will not uncover it. Sheet piled coffer dams and explosives might be utilized in conjunction with the same technology used in the barrier island beach-dune system.

An onland pipeline system consists of a main pipeline, valves, and pressure booster stations, but may also include branch pipelines, loops, multiple mainlines, and/or meter stations.

The onland portion of the pipeline utilizes existing rights-of-way as much as possible. Other factors influencing pipeline route selection include topography, geology and soils, type and number of crossings (water bodies, road and railroad), land use, and environmental concerns.

The general procedure for laying an onland pipeline is:

- o clearing and grading of right-of-way,
- o trenching, generally 12" wider than pipe diameter,
- o stringing and bending of pipe,
- o welding and coating of pipe,
- o padding (of irregular or corrosive trench bottoms with sand, gravel, crushed rock, or screened soils),
- o lowering in of pipeline,
- o backfilling, and
- o revegetation.

When the pipeline crosses bodies of water, roads, or railroads, special pipelaying techniques must be used. Stream crossings may utilize one or more of the following methods:

- o bottom pull
- o floating bridge
- o floating barge, or
- o directionally controlled horizontal drilling.

Road and railroad crossings may utilize several methods including

- o open cutting of roadways (unpaved or lightly travelled),
- o boring under roadways (heavily travelled roads or railroads).

Pipeline right-of-way width depends on such factors as

- o construction requirements,
- o operation requirements,

- o maintenance requirements,
- o engineering requirements,
- o pipe diameter, and
- o soil conditions.

The right-of-way during operation of a 24-inch diameter pipeline in loamy or rocky soil typically will be 75 feet during construction), with a 25-foot width maintained during operation. A 48-inch diameter pipeline typically would require 100 feet and 41 feet for construction and operation, respectively.

Once a pipeline is laid it must be tested to detect any leaks. The pipeline is flooded with water at a certain pressure and sealed for a certain period of time, usually 24 hours for oil pipelines and eight hours for gas pipelines. If there is a drop in pressure over the test period, a leak must be present. All leaks must be located and repaired before the pipeline can go into operation. Each repair job is unique, the choice of repair method depending on a number of factors.

Oil Pipelines and Associated Pumping Stations

Oil pipelines generally are built by the oil companies producing the oil, either on an individual or cooperative basis. Depending on the distance from shore and the amount of activity in the production area, gathering lines may be used to collect oil from a number of production platforms and carry it to a central point from which a larger pipeline carries it ashore.

A pumping station at the production platform, and possibly additional pressure boosters on platforms along the pipeline route, is required to drive the oil onshore. If the pipeline goes an appreciable distance inland, additional pumping stations may be needed near the landfall or along the onland pipeline route.

The number of pumping stations required will depend on the following:

- o length of the pipeline,

- o diameter of the pipeline,

- o characteristics of fluids being transported (i.e., viscosity, specific gravity, and whether single or two phase flow), and

- o bottom characteristics along the route (i.e., slope, topography, depths).

A pumping station may require as much as 40 acres of land and will include storage tanks, an office, and the pumping station itself.

The landfall location for oil pipelines often will be associated with other facilities. If the oil is to be transhipped by tanker, the landfall must be located near a site suitable for a tanker terminal and tank farm. If the oil is to continue by onland pipe to a refinery, a pumping station may be the only facility associated with the landfall.

An onshore oil pipeline may be very inconspicuous after completion, particularly where it does not pass through a wooded area. A 50 to 100 foot right-of-way, either purchased in fee or as an easement, is required for construction of an oil pipeline. Revegetation can be hastened by separation of topsoil and subsoil during

excavation. It is general practice and New Jersey State policy to try to locate the pipeline right-of-way in or parallel to existing rights-of-way of highways, power transmission systems, railroads, other pipelines, or similar facilities.

The diameter of oil pipelines will vary depending on the production rate of the field, the desired operating pressure, and the bottom conditions along the route.

<u>Gas Pipelines and Compressor Stations</u>

Natural gas usually is sold on the platform to a gas transmission company, which builds the pipeline to transport the gas from the platform to its transmission line. Like oil, gas may be collected from a number of platforms by gathering lines and transported to a central manifold platform, where compression may be required before it is sent ashore via a larger trunk pipeline. The onshore pipeline will connect with the existing gas transmission network. Compression may be required along the onshore route to maintain the desired operating pressure of the gas. Onshore compressor stations, fueled by natural gas or refinery gas, require from 10 to 25 acres of land located along the pipeline corridor.

The landfall for gas pipelines usually is located near an existing or potential gas processing plant site. Gas processing plants usually are owned by the producer, who retains the rights to the liquifiable hydrocarbons contained in the gas stream and recovered by processing (see Gas Processing and Treatment Plants).

A 50 to 100 foot right-of-way, either purchased in fee or as an easement, is required for construction of a gas pipeline. It is general practice and New Jersey State policy to try to locate the pipeline right-of-way in or parallel to existing rights-of-way of highways, power transmission systems, railroads, other pipelines, or similar facilities.

The diameter of gas pipelines will vary depending on the production rate of the field, the desired operating pressure, and the bottom conditions along the route.

Gas Separation/Dehydration Plants

Gas separation and dehydration involves separating the gas, oil and free water components of the well stream, and dehydrating the liberated gas to remove water vapor. Free natural gas is obtained from the well stream by a separation process, either by a two-phase process which separates gas from the rest of the well stream or by a three-phase process which results in separate gas, oil, and free water components. Heavy liquid hydrocarbons are settled out in one or a series of separation vessels, each at successively lower pressures. The liberated gas passes through a valve at the phase interface and passes on to the dehydration process. Dehydration, by removing water vapor that remains in the gas stream after separation, prevents the buildup of solid hydrates along the pipelines and minimizes corrosion by the acid gases often present in the gas stream.

Most often these processing facilities are located offshore, because smaller, less expensive pipelines can be used, less energy is required to move a single phase, and pipeline corrosion problems can be minimized. On the other hand, locating these facilities offshore requires that larger platforms be built, so that short

distances to shore may favor a decision to locate the facilities onshore. Both long distances to shore and shallow water depths favor offshore separation/dehydration while short distances and deep water favor onshore separation/dehydration. Leased tracts of interest to New Jersey are generally 50-100 miles offshore in water depths of 150-650 feet. Water depths less than 150 feet and offshore distances less than 75 miles or offshore distances greater than 75 miles or offshore distances greater than 75 miles would favor offshore partial processing (Methodologies for OCS-Related Facilities Planning).

Oil and gas content, and fluid characteristics of the wellstream also play a role in the siting decision. Gas separated on the platform may be used to generate steam and electricity, or may be reinjected to maintain well pressure and increase the oil yield.

Onshore facilities may be located at the pipeline landfall as a separate facility, or together with a marine terminal or gas processing plant. Oil companies generally own and operate these facilities, often as a joint venture between several companies operating in the same area.

A rule of thumb for the amount of land taken up by combined gas/oil onshore partial processing facility is 15 acres for every 100,000 barrels of oil and associated gas, but this figure is inflated because it includes facilities for partial processing of the oil stream and treatment of the water derived from the separation process.

Refineries

Refineries convert crude oil into many petrochemical products ranging from motor fuels and lubricants to stocks for the chemical industry. Refineries are usually located close to product markets such as large urban centers rather than crude oil sources. Refineries will expand existing facilities rather than build new ones. Recent inflation has a major bearing on this decision. The need for a refinery near an OCS region can only be determined after well-head production rates are known. The earliest a refinery would be built after a lease sale is about 8 years, allowing 3-4 years for the exploratory phase to establish the need for a refinery, a year for the selection of a site, and about 3 years to construct it. Refiners seek large sites necessarily near a deep water port or a crude oil pipeline. Per 10,000 bbls/day capacity, roughly 22 acres are needed for refinery buildings and processing units, 13 acres as a buffer to adjacent land uses, and 140 acres for future expansion. The developed portion of a typical refinery site will include processing units, storage tanks, water treatment facilities, offices, machine shop, outdoor storage and warehouses, electrical substation, firehouse, pumping station, truck loading areas, pipelines rail spur and parking areas. Refiners seek sites having low environmental constraints in areas with little or no history of public protest against facility siting. Local business taxes, state taxes and air quality limitations may influence siting decisions. Other factors important to refinery siting are

- access to rail
- access to well-maintained highways
- access to product pipelines
- access to utilities (electricity, water, sewerage)
- presence of support services such as machine shops, value manufacturers, warehouses and contract maintenance.

During the three year construction phase, a 250,000 bbl/day refinery will need an average of 1800-2200 pipefitters, welders, electricians equipment drivers and laborers, up to 70% of whom will be hired locally if in or near an urban area. Upon completion, such a refinery will employ 400-900 workers, most of whom will be hired locally.

Marine Terminals

Marine terminals serve as receiving and shipping areas whenever waterborne shipments of crude oil are involved. Terminals differ from one another in terms of function, size, type of loading/unloading facilities and processing equipment. The functions of a marine terminal may include

- o loading crude oil received by pipeline from offshore platforms onto tankers for delivery to refineries,
- o receiving crude oil from tankers for delivery to refineries by overland pipelines,
- o receiving crude oil from very large carriers or supertankers for delivery to nearby refineries by pipeline, and
- o receiving refined petroleum products from tankers and storing them until overland delivery to markets.

The basic components of a marine terminal may include

- o berthing capacity for vessels,
- o loading/unloading equipment,
- o storage tanks,
- o terminal control & safety equipment,
- o harbor and navigation facilities,
- o partial processing equipment,
- o gas processing plant,
- o deballast water storage and treatment facilities,
- o bunker fuel storage and loading equipment, and
- o railroad facilities.

<u>Pipe-fed Tanker Terminals</u>

This type of marine terminal receives crude oil directly from the production platforms by pipeline. It may be necessary to separate associated natural gas from the oil at the terminal. Gas processing facilities may also be located at the terminal to recover liquifiable petroleum gases from the gas. In this case storage tanks for recovered products will be required. The natural gas may be used to fuel the terminal's processing equipment or may be sold locally. Partial processing facilities also may be used to remove brine water from the crude oil prior to storage. Tankers arriving at the terminal will be carrying ballast water which will need to be unloaded and treated prior to disposal. Storage tanks for this purpose, as well as oil and water separators and possibly flocculation equipment will be provided.

<u>Tanker-fed Receiving Terminals</u>

Crude oil arrives at this type of terminal in tankers. The unloading tankers typically berth at shoreside marine piers and pump their oil into surge tanks, from

which it is piped overland to the refinery. Ballast treatment facilities may not be required since tankers will be taking on, rather than discharging, ballast water. Bunker fuel storage and loading will be provided to fuel the tankers prior to their departure.

Marginal or shoreside fixed pier. This type of pier is usually found inside a harbor, and is oriented either parallel or perpendicular to the shoreline. The orientation depends on the following:

- o current in the channel or basin,
- o width of harbor channel,
- o availability of land,
- o availability of tugs, and
- o prevailing wind direction.

The pier consists of loading platform, breasting dolphins and mooring dolphins, connected to each other by steel truss walkways. It is connected to the shore by a trestle, which serves as access from the shore to the loading platform and supports all piping. The loading platform itself is built on pilings and supports

- o loading arms,
- o piping valves,
- o surge relief tanks,
- o operation control building,
- o loading arm control room,
- o firefighting equipment,
- o lighting towers,
- o instrumentation, and
- o operating equipment.

The breasting dolphins, the structures against which the vessel berths, are concrete or steel platforms attached by steel truss walkways to the loading platform and by pilings to the seabed. The breasting dolphins may be either rigid and equipped with compressible rubber fenders or other device to absorb impact energy, or flexible and constructed of vertical flexible steel piles with a steel platform. The berthing vessel's mooring lines are attached to mooring dolphins, which are steel pile-supported concrete structures that transmit the tanker mooring forces resulting from wind, wave, and sea conditions. Steel truss walkways connect the mooring dolphins to the loading platform.

Other types of mooring facilities are discussed below.

Sea island piers. Sea island piers are fixed structures constructed basically the same as shoreside or marginal piers, except that they are not connected to the shore by a trestle. They are generally of concrete deck construction supported on steel or concrete piles, and their foundations are either drilled and anchored into rock or driven deep into the sea bottom. Submarine pipelines transport the crude oil to shore. An advantage of the sea island pier design is that both sides of the pier are available for mooring. These piers must be carefully oriented to the most favorable wind, wave, and current. As with marginal piers, tug boats are required for safe berthing.

Single point moorings. There are several types of single point moorings which may be used in transferring crude oil from tankers to pipelines. All include as

components an anchored floating buoy, floating hoses for connecting the tanker manifold to the buoy, and undersea hoses connecting the buoy to submarine pipelines. The oil is transferred through the pipeline to onshore storage tanks. The most common types of floating moorings are single point moorings. The tanker is attached to the buoy with bow anchor lines, and is free to weathervane around the buoy. One type of single point mooring is the single anchor leg mooring (SALM), attached by a single anchor leg to a base on the sea floor. Universal joints in the structure permit the hoses and base to swivel with the movement of the ship, helping to prevent the ship from fouling the lines.

Another floating mooring, the caternary anchor leg mooring (CALM), is anchored by six to eight pretensioned chains attached to piles driven into the sea bottom. Vessels are moved to a turntable that allows it to swing freely to orient into the prevailing wind, current, sea and swell.

A third single point mooring system, but one which is not free floating, is the single point mooring pier. It consists of a floating boom mounted by a semi-submersible floating arm to a pylon or tower that is fixed to the sea floor. The floating arm is attached to the fixed tower by a swivel arm, allowing the moored tanker to feather into the wind, current, and sea swell. The rigid truss structure eliminates the problem of hose vulnerability to damage by the tanker.

Deep Water Terminals

Supertankers and very large crude carriers (VLCC's), because of their deep draft, require corresponding deep water. Few natural harbors can meet their requirements, so most deep water terminals are constructed offshore. They are generally in water 100 feet or more deep and may use either a fixed sea island pier, or a floating mooring system. The crude oil cargo is transferred by pipe to a surge tank farm. These tank farms generally have a larger storage capacity than in other types of marine terminals to correspond to the large size of the tankers being accommodated. Deep water terminals are only considered in this study to the extent that they are feasible within Raritan or Delaware Bays or the three-mile limit.

Product Terminals

Product terminals receive waterborne shipments of petroleum products from refineries for distribution to major petroleum market areas. The vessels used for transporting these products are smaller than crude oil carriers and have shallower draft requirements. Storage tanks for these products are generally smaller than those at a crude oil terminal, but a greater number of tanks will be required in order to store the greater number of products separately. Tank trucks, rail cars, or small coastal vessels distribute the products to the market, so the appropriate transport system must be readily accessible.

Tank Farms

Oil storage tank farms may be located at a number of different facilities, depending on the oil processing and transportation schemes being used. If oil is piped to shore, tank farms may be located near the pipeline landfall, associated either with pumping stations or with marine terminals from which the oil will be transshipped to refineries in other regions. In the latter case, storage tanks for

ballast water from the arriving tankers will also be provided. At marine terminals that receive crude oil via barge or tanker, the crude is pumped into surge tanks, from which it will be piped overland to the refinery. The use of surge tanks allows the tankers to unload as quickly as possible, reducing berthing time. A smaller crude pipeline can be used and a steadier pumping rate can be maintained when the oil is pumped from storage tanks. Associated with these crude oil receiving terminals will be bunker fuel storage and loading facilities.

The oil stored onshore, whether arriving through a pipeline or by tankers, may undergo partial processing. The partially processed oil is pumped to a tank where it is stored until being transported to the refinery.

Tank farms also are essential elements of refineries and petrochemical plants, in the first case storing incoming crude oil for refining or in the latter case storing refined petroleum petrochemicals. The refinery products or petro chemicals must be stored prior to distribution by pipeline, rail, ship, barge, or truck.

The storage tanks themselves may be one of three basic types--fixed roof tanks, floating roof tanks, and variable vapor space tanks.

Fixed Roof Tanks

A fixed roof tank is a cylindrical steel container with a conical roof. It is equipped with a pressure/vacuum vent to allow excess gases to escape. This is the least expensive type of storage vessel.

Floating Roof Tanks

A floating roof tank is a cylindrical steel container with a roof that "floats" up and down with the changing amounts of vapor in the tank. Mechanical seals seal the space between the roof and the walls, but often a fixed roof is also provided to further reduce gaseous emissions.

Variable Vapor Space Tanks

This variable vapor space tank is designed to respond to the amount of vapor present above the liquid surface. Unlike the floating roof design, it is equipped with a diaphragm or "lifter" roof. It is used for storing petroleum products other than crude oil.

The size of a tank farm depends on a number of factors, including

- production rate of the field,
- throughput rate of the pipeline serving the terminal,
- size of the tankers using the facility,
- number of berths,
- arrival frequency of the tankers,
- number of days necessary to store the oil should transshipment to tankers be interrupted, and
- whether or not it is necessary to separate crude produced at different fields.

The following table indicates the approximate land requirements for tank farms of various sizes.

APPROXIMATE LAND REQUIREMENTS FOR TANK FARMS

Tank Farm Capacity (barrels)	Land (acres)
1,000,000	17
2,000,000	37
3,000,000	50
3,500,000	58

Source: Arthur D. Little, Petroleum Development in New England, 1975, Vol. II, p. IV-7.

Gas Processing and Treatment Plants

Natural gas as it comes from the ground is often associated with other substances. Assuming commercial quantities of offshore gas are found, some separation will probably be done offshore (see Gas Separation/Dehydration Plants). If gas is associated with oil or water, it will be separated and dehydrated. If it is not associated with oil or water, it will simply be piped ashore.

When the gas reaches shore, it will be further treated and purified and then repressurized for transmission to market. If the gas is rich in liquifiable hydrocarbons, such as propane and butane, it may be economically attractive to separate them. If the gas arriving from the production platform is "sour" gas, or has a high sulfur content, then it must be "sweetened," or treated to remove the sulfur compounds. Hydrogen sulfide, a product of this treatment, may be converted to elemental sulfur in a sulfur recovery plant and sold commercially. If only a small amount of hydrogen sulfide is recovered, it may be flared or incinerated.

Generally the processing facility is built by the producer, who retains the rights to the liquifiable hydrocarbons derived from the processing, while the gas transmission company to which the gas has been sold constructs the gas pipeline.

Gas processing and treatment facilities are designed for the specific gas stream being received. Thus, there is a great deal of variation in size and design of these facilities. The throughput capacity typically ranges from two million cu.ft./day to two billion cu.ft./day. Three processes commonly used to recover natural gas liquids are

- o lean oil absorption,
- o mechanical refrigeration, and
- o cryogenic refrigeration.

(These processes are described in the NERBC's Factbook.) The richness, or amount of liquifiable hydrocarbons in the gas stream, and the desired rate of recovery determine which process is used.

While the gas processing facilities in themselves do not require a lot of space, a large amount of land is required as a buffer for safety reasons. For example a plant with a billion cu.ft./day throughput may require a 75 acre site, of which only 20 acres is occupied by buildings and structures. Other land uses include areas for

- loading,
- storage,
- offices,
- parking,
- communications,
- compressors, and
- generators.

The site may either be coastal or inland, but must be located between the pipeline landfall and the commercial transmission lines into which the processed gas will be delivered.

APPENDIX C. THE STATUS OF EMISSIONS INVENTORIES IN THE CAPE FEAR REGION

The following documents relating to air emissions inventories were reviewed for completeness and consistency:

- A print-out titled "Emissions Report by Plant for North Carolina", consisting of 20 pages and dated 8/1/80. (Report A)
- A print-out of computerized EPA Region IV EIS data AQDM Format. (Report B)
- Directory of Manufacturers and Processors in the Greater Wilmington Area, January 1979.
- Working List of Air Pollution Sources in Brunswick, Columbus, New Hanover, and Pender County. Provided by DNR&CD (Wakild to Reilly, May 15, 1980).

The computerized emissions inventories provided by the Cape Fear Council of Governments have been evaluated for adequacy as required input to a regional air quality modeling program. In general, most major sources, as cross-referenced in the Directory of Manufacturers and Processors in the Greater Wilmington Area, appear to be covered when both print-outs are considered. It appears that the information provided is generally adequate and could readily be utilized to initiate start-up and check-out procedures for dispersion modeling.

We would like to point out some difficulties in these data. For instance, Report A contains information on five criteria pollutants (TSP, SO_2, NO_x, HC, CO), while Report B covers only two pollutants (TSP, SO_2). Report A contains sources that are not covered in Report B and vice-versa. This may be due to the time frame in which these data were collected or updated. It would be quite useful, however, if all the information could be provided in one single data base.

It is possible that some or all of this required information is actually in residence in DNR&CD's data bank but was simply not included on the print-out we received. It is also possible, based on earlier telephone conversations with DNR&CD, that the required information exists in "hard copy" files and has not been entered into the data bank as of yet.

Based on our review of the above-mentioned documents, we note the following:

- Source sizes listed appear to be those emitting one ton per year or more of any of the five major pollutants (TSP, SO_2, NO_x, CO, HC).

o In Report A,* there are 42 sources of one ton/year or more emissions listed for county code 2880 (New Hanover County). Twelve sources are listed for county 0460 (Brunswick County), fifteen sources for county 0880 (Columbus County), and six sources for county 3100 (Pender County).

o In Report B,* the following sources of one ton/year or more were found: Fourteen sources are listed for county code 0460 (Brunswick), ten sources for county 0880 (Columbus), forty-six sources for county 2880 (New Hanover), and five sources for county 3100 (Pender).

o Emissions are defined only in terms of mass per year. Shorter term maxima or seasonal variations are not reported.

o Some information is missing, such as UTM coordinates, flow rates, etc. for some major sources, e.g., point sources 13-16 for DuPont Cape Fear Plant. Wright Chemical Corporation in Riegelwood emitting 93 tons of SO_2 has no flow rate or stack height given for its point source #4.

Comparison of the above characteristics of the inventory with criteria established in Chapter 2 reveals the following findings:

Criteria: The emissions inventory must treat the particular pollutants which will likely be emitted by new energy-related facilities.

Finding: The inventory as found on the print-out is adequate with respect to the types of pollutants quantified except for lead. Lead is a criteria pollutant and may be an important consideration should a major facility, such as a coal-fired facility, or facilities have to be evaluated.

Criteria: The information obtained must be of sufficient spatial and temporal resolution to permit siting decisions through use of air quality dispersion modeling.

Finding: The information is sufficient to perform predictions of annual average pollutant concentration due to major point sources. However, the information presented is of insufficient temporal resolution to be of use in determining shorter term (seasonal, monthly) air quality conditions. Emissions of many sources vary seasonally and this is not shown.

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*Note: The number of sources in Reports A and B are actually the number of facilities. Each facility may have more than one point source listed. Some listed facilities have no point sources listed for TSP or SO_2 but they may have other contaminant emissions which do not appear on the Region IV inventory.

When we compared the State inventory print-out (Report A) to the Region IV inventory (Report B), the latter one lists two additional facilities in Brunswick County, five less in Columbus County, four more in New Hanover, and one less in Pender County.

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In addition, the following information should also be made available:

- o Name of contact at source and telephone number;
- o Year and month of information receipt or update.

Regarding the general content of the inventory, two observations are made. First, no area source emissions data have been received. These data may not currently be in computerized form but they must be available if dispersion modeling of the COG region is to eventually be performed. Second, there appear to be possible omissions in the point source inventory for the four county area. For example, in Columbus County, comparison of the listings in the "Directory of Manufacturers and Processors in the Greater Wilmington Area" (published by the Greater Wilmington Chamber of Commerce and dated January 1, 1979) with the emissions inventory listing reveals the following areas of concern:

- o Omission of Allied Chemical in Riegelwood
- o Omission of Kaiser Agricultural Chemicals in Riegelwood
- o Apparent omissions of relatively large employers, textile industries such as Blue Jeans Corporation in Whiteville and Ithaca-Chadbourn in Chadbourn, both in Columbus County. Based on the number of employees, these two manufacturers may emit more than one ton of SO_2 per year for space heating purposes unless natural gas is used, in which case, NO_x emissions may exceed one ton per year.

Other potential omissions include France Neckwear Company in Wilmington (An employer of between 500 and 1,000 people) and Maritime Lumber Service (kiln drying) also located in Wilmington.

Recommendations

It is recommended that the possible deficiencies identified in the emissions inventory be investigated with the DNR&CD at a later date prior to final use of data in a regional modeling effort. As mentioned previously, much of the required data may be available but not included on the print-out.

Area source emissions data must be available for meaningful dispersion modeling.

In the case of the possible omission of sources, it is suggested that the specific sources mentioned above as not being included in the inventory be surveyed on an informal basis to determine the propriety of their omission. Given the COG's intimate knowledge of the local industry, this could be accomplished without excessive effort. If the omission of any of these sources in this "sample" of potentially omitted sources is found to be unwarranted, the deficiency should be brought to the knowledge of the DNR&CD for correction and the inventory should be reviewed in detail for other obvious omissions.

CEIP Publications

1. Hauser, E. W., P. D. Cribbins, P. D. Tschetter, and R. D. Latta. Coastal Energy Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #1. September 1981. $10.

2. P. D. Cribbins. A Study of OCS Onshore Support Bases and Coal Export Terminals. CEIP Report #2. September 1981. $10.

3. Tschetter, P. D., M. Fisch, and R. D. Latta. An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone. CEIP Report #3. September 1981. $10. (Available spring 1982)

4. Cribbins, P. S. An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #4. September 1981. $10.

5. Brower, David, W. D. McElyea, D. R. Godschalk, and N. D. Lofaro. Outer Continental Shelf Development and the North Carolina Coast: A Guide for Local Planners. CEIP Report #5. August 1981. $10.

6. Rogers, Golden and Halpern, Inc., and Engineers for Energy and the Environment, Inc. Mitigating the Impacts of Energy Facilities; A Local Air Quality Program for the Wilmington, N.C. Area. CEIP Report #6. September 1981. $10.

7. Richardson, C. J. (editor). Pocosin Wetlands: an Integrated Analysis of Coastal Plain Freshwater Bogs in North Carolina. Stroudsburg (Pa): Hutchinson Ross. 364 pp. $25. Available from School of Forestry, Duke University, Durham, N. C. 27709. (This proceedings volume is for a conference partially funded by N. C. CEIP. It replaces the N. C. Peat Sourcebook in this publication list.)

8. McDonald, C. B., and A. M. Ash. Natural Areas Inventory of Tyrrell County, N. C. CEIP Report #8. October 1981. $10 for all requests.

9. Fussell, J., and E. J. Wilson. Natural Areas Inventory of Carteret County, N. C. CEIP Report #9. October 1981. $10 for all requests.

10. Nyfong, T. D. Natural Areas Inventory of Brunswick County, N. C. CEIP Report #10. October 1981. $10 for all requests.

11. Leonard, S. W., and R. J. Davis. Natural Areas Inventory for Pender County, N. C. CEIP Report #11. October 1981. $10 for all requests.

NOTE: Please note renumbering of reports 5-10.

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